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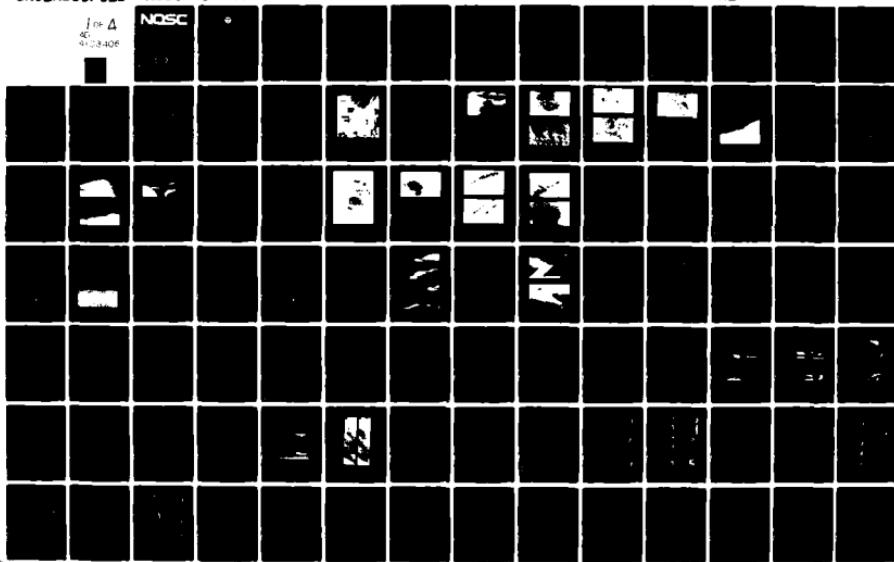
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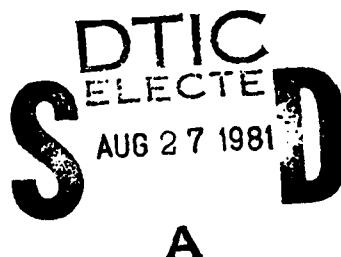
Technical Document 449

AERIAL SURVEYS OF ENDANGERED WHALES IN THE BEAUFORT SEA, CHUKCHI SEA AND NORTHERN BERING SEA

JUNE 1981

DK Ljungblad

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Final Report: Fall 1980

Prepared for
Bureau of Land Management

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Aerial surveys and acoustic recordings of bowhead whales and other marine mammals were made from 17 April to 4 November 1980 in the Beaufort, Chukchi, and Bering Seas. The spring and fall migrations past the lease areas were monitored closely to determine whale distribution. Ice conditions, which are fully discussed, radically changed the migration pattern from that of the 1979 season. Unusual and distinctively marked whales were noted during the spring and fall migrations, and a stranding was investigated. The 1979 acoustic recordings have been analyzed and are provided in an appendix.		

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NOSC Participants

Frank Shipp of NOSC Code 5131 conducted survey flights 23 through 45 from 29 May to 15 July 1980, and prepared the draft report of the relevant section for the final report.

Mary F. Platter-Rieger of NOSC Code 5131 conducted survey flights 56 through 65 from 29 July to 8 September 1980, and survey flights 89 through 107 from 11 October to 4 November 1980, and prepared the draft report of the relevant sections for the final report. Also, she performed the preliminary analysis of the 1980 bowhead whale density estimate.

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Three personnel from Computer Sciences Corporation, San Diego, CA, also provided technical advice and assistance. D. Rick Van Schoik who interpreted initial distribution and abundance parameters as well as coordinating tables and graphics. Clark S. Winchell provided statistical analysis of sighting information for a density estimate. Sue E. Moore reviewed and edited extensive portions of the manuscript and provided acoustic analyses of sound recordings.

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INTRODUCTION

The bowhead whale, Balaena mysticetus, inhabits the Bering, Chukchi, and Beaufort Seas. Bowheads migrate annually in the spring (April, May, and early June) from the Bering Sea north and east into the Beaufort Sea, and east to the MacKenzie Delta - Banks Island area and the Amundsen Gulf area located in Canadian waters. In early or mid-September, they make a westerly return migration from Canadian waters past Point Barrow, and south to the Bering Sea.

These migrations take bowheads through or near areas currently being assessed as potential sources of mineral and oil resources. As the bowhead is protected under both the Endangered Species Act and the Marine Mammal Protection Act, there is concern that resource-related development associated with such activities may have an effect on whales that frequent these areas. A brief account of the history and the habits of the bowhead is provided in appendix A.

BACKGROUND

In 1979, the Bureau of Land Management (BLM) funded the Naval Ocean Systems Center (NOSC) to conduct a study to determine occurrence, estimate population density and distribution, observe behavior, and record sound production patterns of bowheads in the vicinity of the proposed Joint State-Federal Beaufort Sea oil lease area. Using aerial survey methods, north-south line transects were flown in and about the oil lease area.

In the spring of 1979 (April, May) the area of study was covered with ice. Therefore the main efforts were to follow the migration east and to obtain recordings of bowhead sounds. In the fall of 1979 (September, October) the migration route and nearshore distribution of the whales were observed from the Canadian border to Point Barrow.

For a discussion of the 1979 study, see Ljungblad et al, 1980.

ACOUSTICS

Bowhead sounds were recorded for the past 2 years during the spring and fall migrations. The sounds recorded in 1979 have now been analyzed and are described in appendix B. This will also be the subject of a pending publication in open literature.

CURRENT STUDY

From mid-April to mid-November of 1980 the study was continued. The survey effort was expanded to include the proposed Beaufort Sea Federal Sale 71 lease area and portions of the Chukchi and northern Bering Seas. This document describes the study and presents its results. All surveys made during this period are shown in detail in appendix C.

METHODS

OBJECTIVES

The objectives of this study are to investigate the occurrence, population density, distribution, and behavior patterns of endangered whales in and about the Beaufort Sea oil lease areas, the proposed Norton Sound oil lease area, the Norton Basin - St. Lawrence Island area, the Hope Basin, and coastal portions of the Chukchi Sea.

DESIGN

The areas of study are listed below; their geographical locations are shown in figure 1.

- a. Block 1 includes the Joint State-Federal Beaufort Sea oil lease area.
- b. Block 2 includes the proposed Beaufort Sea Federal Sale 71 oil lease area.
- c. Block 3 covers the suspected spring migration route from Point Barrow to the Canadian border.
- d. Block 4 covers the Hope Basin and the coastal strip to Point Barrow.
- e. Block 5 covers the proposed Norton Sound oil lease area.
- f. Block 6 encompasses the Norton Basin - St Lawrence Island area.

The major emphasis of the surveys was in blocks 1 and 2, (30 and 19 flights, respectively), which encompass the Beaufort Sea oil lease areas. Block 3 was surveyed extensively (26 flights) during the spring in an attempt to determine the easterly migration route. Blocks 4, 5, and 6 (8, 5, and 6 flights each, respectively) were surveyed mainly before the spring and fall migrations.

PLANNED SURVEYS

The procedure for designing the aerial surveys was the same as that used for the north-south transects flown during the spring and fall of 1979 (Ljungblad).*

The specific areas to be surveyed, with the exception of block 3, were divided into sections that were 18.5 km (10 nmi) in width and laid out to cross suspected migratory routes. Transects were chosen within each section

* NELC TD 314, Aerial Surveys of Bowheads Whales, North Slope, AK, by Ljungblad, DK, MF Platter-Rieger, and FS Shipp, Jr, Unclassified, February 1979

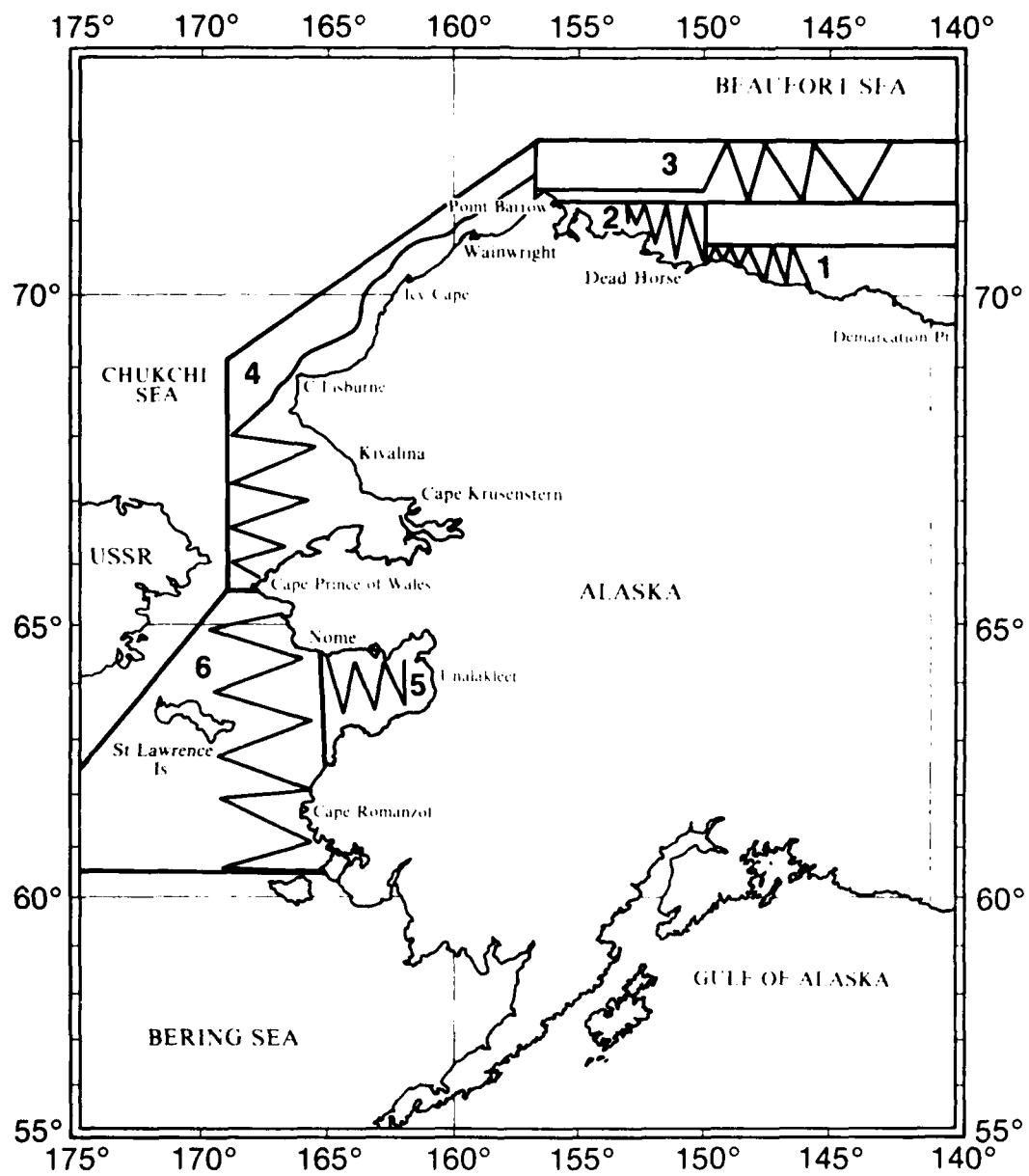


Figure 1. Study areas; zigzag lines represent the general directions of the surveys in each area.

by picking two numbers between 1 and 20 from a random numbers table, matching them to the numbered marks placed at the top and bottom of the section chart, and then drawing the transect line between them. The same procedure was followed for each section within the area to be surveyed; then all of these transects were linked together with short transects at top and bottom. A sample of the basic survey design (Leatherwood, 1979) is shown in figure 2.

Block 3 was surveyed randomly at first, in an attempt to trace the spring migration east from Point Barrow. Once the specific direction and area of the migration were established, the random surveys were discontinued. At this time north-south transects were flown between latitude $71^{\circ}20'00''$ N and $72^{\circ}00'00''$ N, and east to longitude $141^{\circ}00'00''$ W from Point Barrow.

PROCEDURES

Prior to each survey flight, the selected transect positions (turning points) were programmed into the aircraft's navigation system which was then calibrated at a known location. Surveys were flown at altitudes between 80 and 305 m (350 and 1000 ft), averaging 244 m (800 ft). The intention was to maintain 305 m (1000 ft) of altitude but flights varied according to weather conditions. Airspeeds varied between 183 and 201 km/h (114 to 125 knots).

The observers and the pilot (who also acted as a limited observer) were positioned so that the person who was navigating was in the copilot's seat, with the other observers in a left-rear, right-rear arrangement. The pilot and all observers were connected to a common communication system; each observer, except the pilot, was provided with a clinometer and an observation log.

For all marine mammals sighted, whether whales, polar bears, or pinnipeds, the following information was recorded whenever possible: species identification, position coordinates, time, and number in the group. For whales, a clinometer angle was taken when the sighting was abeam of the aircraft. The altitude and magnetic heading of the aircraft along with the transect side where the sighting occurred were recorded, in addition to the heading of the whales relative to that of the plane. Notations were also made regarding the whales' behavior.

On sightings of one or more bowheads, a sonobuoy was dropped and an acoustic recording was made as the aircraft circled the area. In addition, during most survey flights one or two sonobuoys were dropped at random in areas where no whales were sighted in an attempt to check acoustically for their presence.

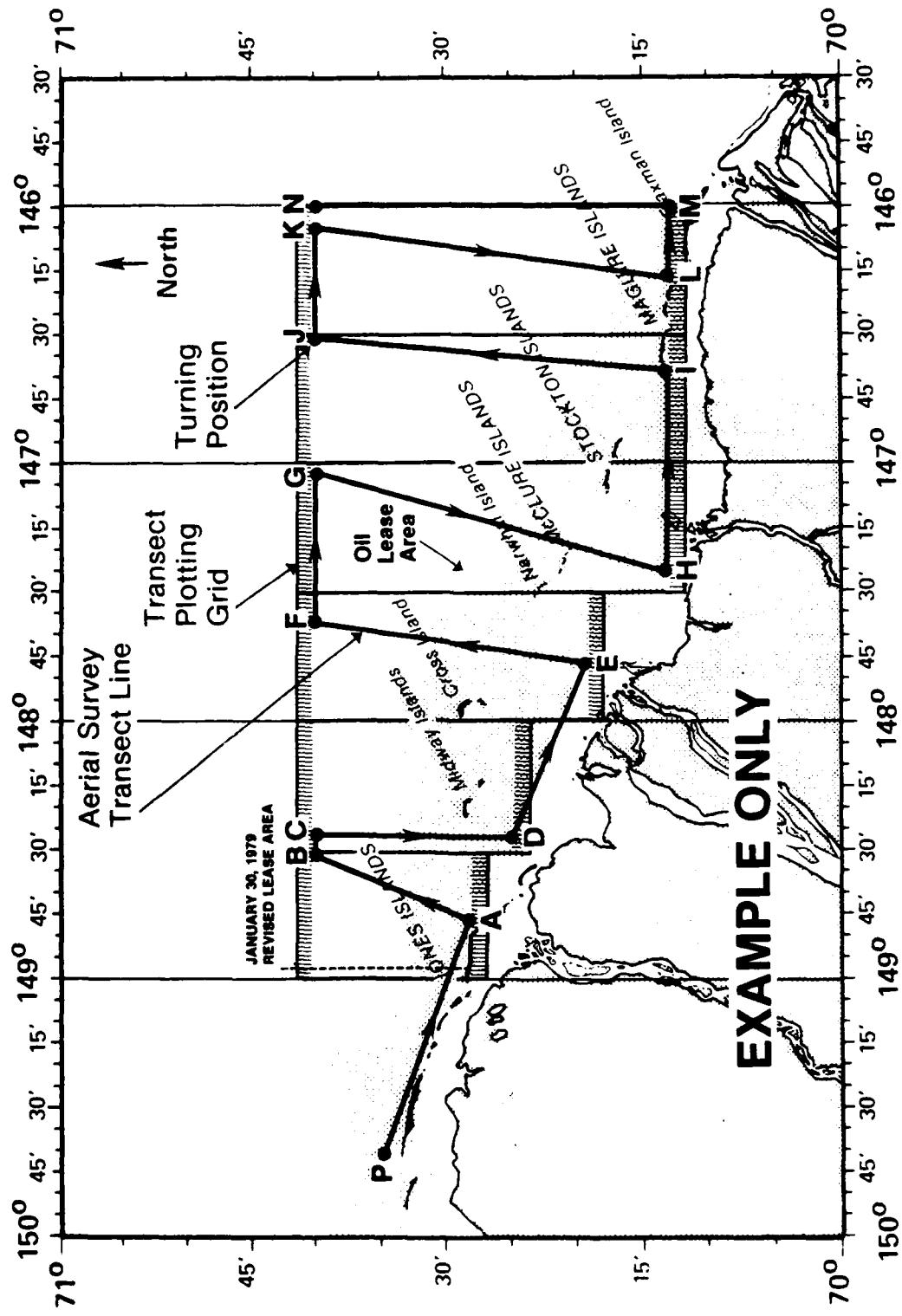


Figure 2. Sample survey design.

ICE CONDITIONS

Ice conditions were determined and recorded using the techniques described in Aerial Ice Reconnaissance (1956).

AIRCRAFT

The aircraft used in this study was a Grumman Turbo Goose provided by the Office of Aircraft Services, Anchorage, Alaska. It was equipped with a global navigation system, which provided a continuous position update, along with the distance from the aircraft position to a transect point and a correction for the aircraft's drift from the programmed course. The accuracy of this navigation system is 0.37 km/hr (0.2 nmi/hr).

SOUND RECORDING EQUIPMENT

AN/SSQ 41A and AN/SSQ 57A sonobuoys were used successfully for recording the sounds of bowheads. Each sonobuoy consisted of a passive listening unit which contained a hydrophone array and a VHF transmitter. The sonobuoys were dropped from an aircraft by means of a rotochute or parachute; once in contact with water, a seawater-activated battery energized the unit. At this time, the parachute assembly jettisoned and the hydrophone array dropped to a preselected depth of 18.2 to 91.4 m (60 to 300 ft). The sounds picked up by the hydrophones were amplified and transmitted to the aircraft's VHF broadband receiver, the output of which was coupled to a Nagra SJ recorder.

SPRING SURVEYS
(APRIL, MAY, JUNE)

POINT BARROW/NOME BASES OF OPERATIONS

The 1980 BLM bowhead whale surveys began on 17 April with the base of operations located at Point Barrow, Alaska. The bowhead whale ice census camps of the National Marine Fisheries Service (NMFS), located on the shorefast ice west of Point Barrow, reported no whale sightings for several days. Therefore, 17 through 27 April was a period of minimum survey effort. Ice conditions during this period consisted of small leads west of Point Barrow that were mostly covered with grease ice. On 26 April, concentrations of bowheads were reported in the Bering Straits. Because the bowheads were migrating later than the usual period of mid-April to late May, the base of operations was moved to Nome, Alaska, where it remained from 28 April through 15 May.

On 28 April, enroute to Nome, the coastal leads were followed from Point Hope to 20 km (11 nmi) south of Kivalina. The entire area from this point to the village of Wales was icebound. Figure 3 shows the typical ice conditions of the Bering Sea, Norton Sound, Bering Straits, and Chukchi Sea during this period.

Detailed information on each survey is shown in flight tracks 1 through 38 in appendix C. Table C-1 lists survey details such as flight hours logged, downtime, type of flight, and overall flights completed. The total number of sightings and total number of individuals for the spring are listed according to species in table 1.

Bering Straits Surveys

After the base of operations was established at Nome, several survey flights to the Bering Straits were completed. During this period, daily contact was maintained with scientists based in Point Barrow, both to inform them of conditions in the Straits and to receive reports on whale sightings near Point Barrow.

Ice totally covered the area extending across the Bering Straits from Cape Prince of Wales to the north end of Little Diomede Island. Large concentrations of pan ice with a 7/10 coverage extended southward, separated from the solid ice edge by a corridor of open water stretching from east to west. There was little change in ice conditions across the main area of sightings between Wales and Little Diomede Island throughout the survey effort.

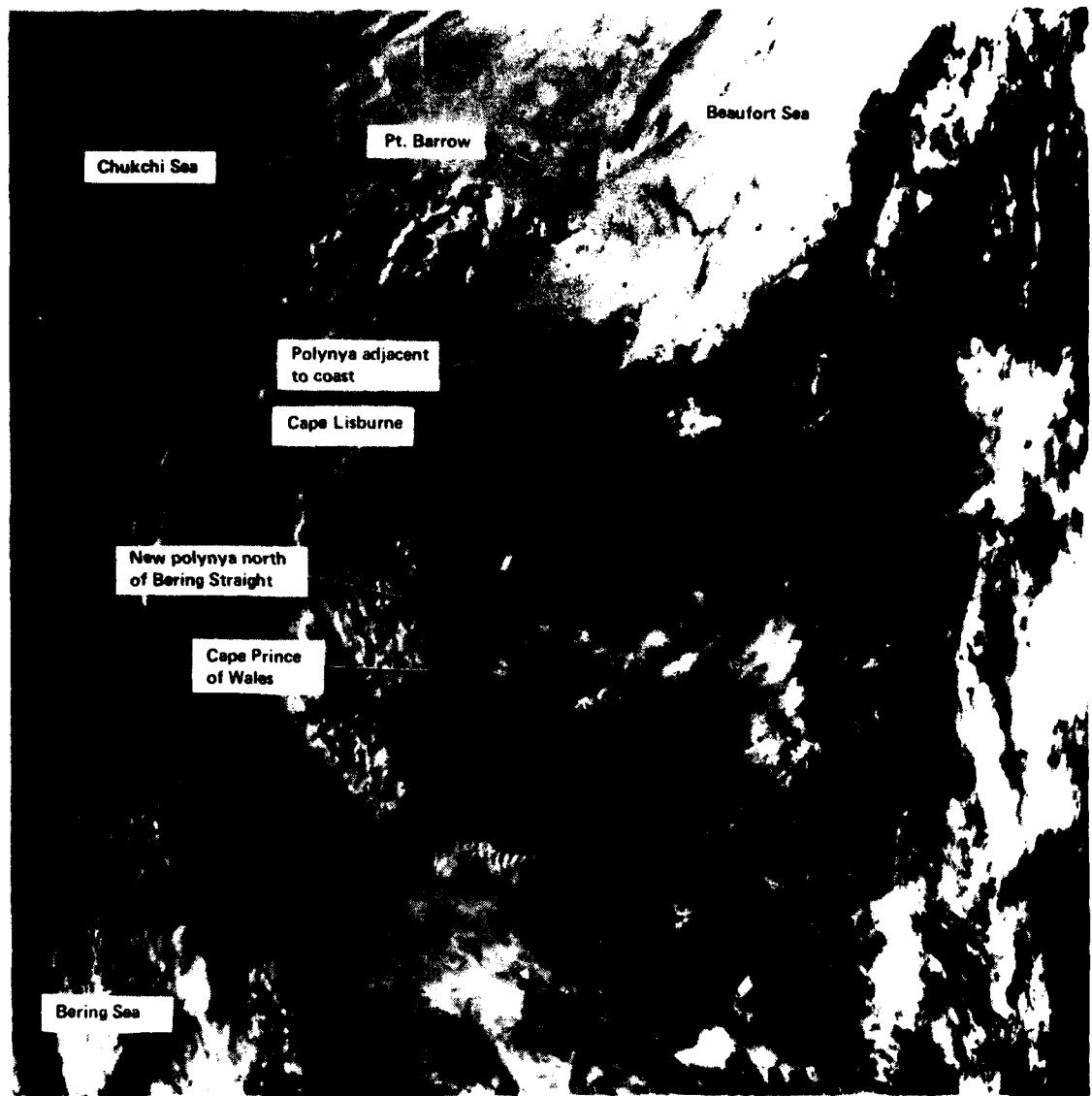


Figure 3. Satellite image of spring ice conditions of Bering Sea, Norton Sound, Bering Straits, and Chukchi Sea on 14 May 1980.

Table 1. Spring marine mammal sightings.

Species	Total Sightings*	Total Individuals*
Bowhead Whale <u>Balaena mysticetus</u>	314	857
Beluga Whale** <u>Delphinapterus leucas</u>	284	3404
Gray Whale <u>Eschrichtius robustus</u>	2	6
Ring Seal <u>Phoca hispida</u>	250	765
Bearded Seal <u>Erignathus barbatus</u>	45	71
Polar Bear <u>Ursus maritimus</u>	5	9
Walrus** <u>Odobenus rosmarus</u>	45	695

*All counts include possible resightings.

**Partial counts.

Enroute to the Bering Straits, the flights passed near the coastal shorefast ice from Nome to Cape Prince of Wales. Numerous bowheads were sighted in the Port Clarence area, within 2.5 km (1.3 nmi) of shorefast ice and heading consistently southward. Nearly all of these whales responded to the aircraft by diving. Numerous belugas were also sighted in this area, generally as individuals or groups of three to seven. Their headings were generally south, but were not as consistent as those of the bowheads.

The first survey to the Straits was flown 1 km (0.5 nmi) off of the ice edge from east to west; that is, from Wales to the north end of Little Diomede Island (figure 4). Eighty-five bowhead whales were counted on this first survey. The same flight pattern was repeated on later flights to obtain a count of the whale population along the ice edge between Cape Prince of Wales and Little Diomede Island.



Figure 4. Bering Straits: ice edge, looking southwest toward Little Diomede Island.

Concentrations of bowheads, belugas, and walruses were frequently seen in the open water area near the ice edge. The belugas were observed in groups averaging five to eight animals, except for occasional groups of 30 or more. Walruses were seen in groups of 25 or more, increasing to hundreds along the ice edge by 13 May.

The bowheads were generally very active and concentrated within a small area, so that it was difficult to count them accurately; we believe that the counts are low in areas of high activity. Their activities included breaching, spy-hopping, and floating on their backs with a flipper extended above the surface of the water. Figures 5 through 7 show examples of this behavior.

Groups of bowheads were also milling around in tight circles, causing considerable turbulence and spray. Sexual activity similar to that described by Everitt and Krogman (1979) was apparent in many groups numbering up to six animals. Often these groups consisted of two pairs of apparently mating whales side by side, while the others remained still or swam around them (figures 8 and 9). Motionless whales were common, both in open water and in broken ice. Also, no feeding behavior was noted, so that we concluded that most of the activity was sexually related.



Figure 5. Bering Straits: bowhead breaching.



Figure 6. Bering Straits: bowhead rolling showing flipper.



Figure 7. Bering Straits: bowhead blowing and spy-hopping.

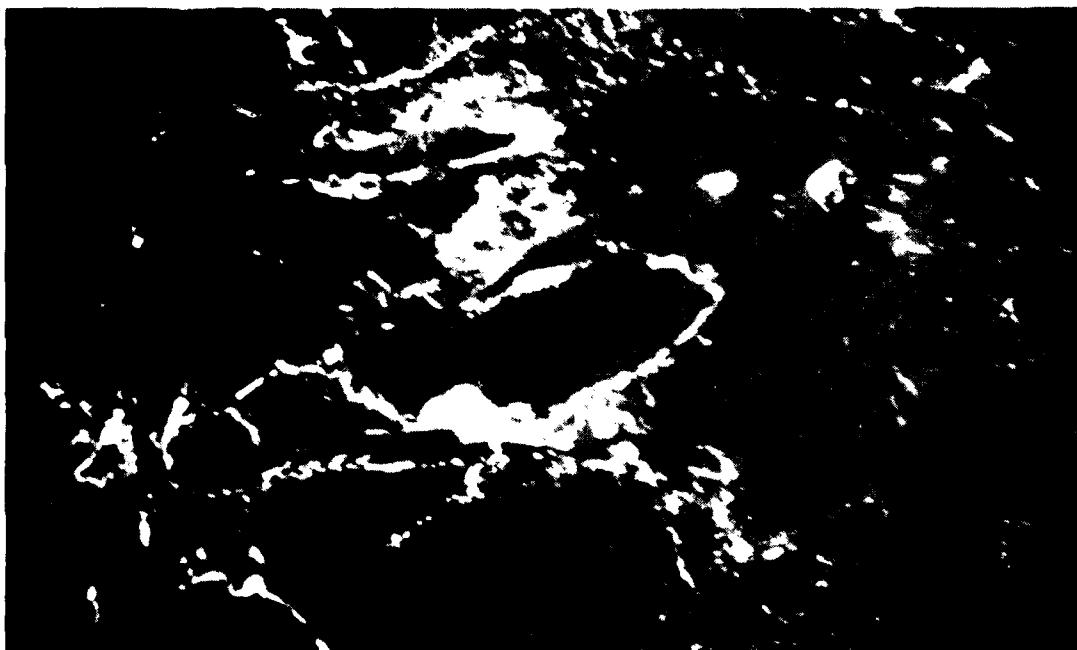


Figure 8. Bering Straits: suspected copulation among two pair of bowheads with accompanying individual.

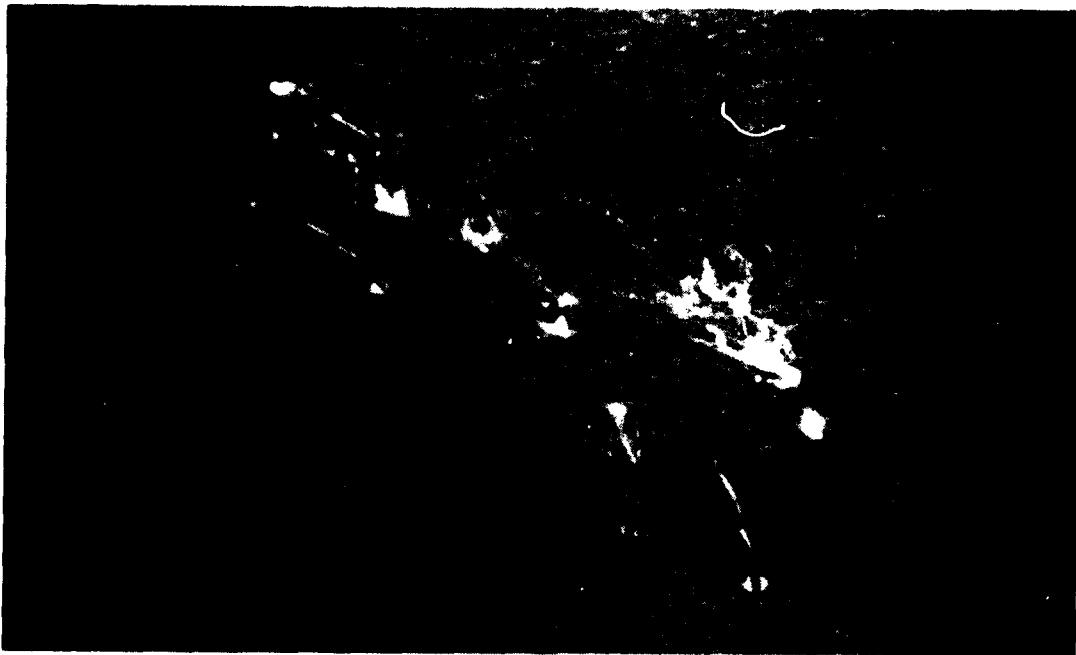


Figure 9. Bering Straits: bowhead group, rear pair possibly copulating.

Throughout this period of surveys, ice conditions remained basically the same, with the exception of some open water toward the Soviet side of the Straits. The numbers of whales in the area, the general locations of sightings, and the behavior of the whales also did not change.

By 13 May the open water corridor between Cape Prince of Wales and Little Diomede Island closed up to within 3.3 km (1.6 nmi) of the north end of Little Diomede Island. Also, the Soviet side of the ice edge had opened up to the northwest of Big Diomede Island. One small lead located near the north end of Little Diomede Island ran toward the northwest, where it connected to the open water on the Soviet side of the international date line. Small groups of belugas were heading northwest in this 30-m wide (99-ft) lead. A huge polynya was located 60 km (32 nmi) northeast of Little Diomede Island; in spite of a thorough search of this area no bowheads were seen.

On 13 May the majority of sightings were concentrated in two areas near Little Diomede Island that were connected by the only existing lead. One of these areas covered about 4 km^2 (1.6 mi^2) of open water and contained large concentrations of bowheads. These whales were very passive, seemingly asleep. Numerous whales were observed with their chins almost touching the ice edge and lying perfectly still,

facing north. Four other large groups of whales were observed; all individuals were separated by several meters, lying still, and pointing north. The second large concentration of bowheads was slightly northwest of Little Diomede Island. Their behavior ranged from very passive to very active. Approximately 2/3 of the whales were lying still near or next to the ice edge, as in the earlier sightings (figure 10). The other whales were milling around in groups of three to five, breaching repeatedly, floating on their backs, spy hopping, and submerged beneath other whales. The majority of the whales seen in these areas were estimated to be 12 to 13 m (40 to 43 ft) in length.

On 15 May the small lead near Little Diomede Island had closed up. A new lead had opened north of Cape Prince of Wales which ran northeast toward the large polynya sighted 2 days earlier. Two bowheads were sighted along this lead heading northeast. The ice between the original ice edge and the large polynya to the north was quite broken up and contained many small cracks and holes. Numerous belugas and bearded seals were observed in the area of these cracks and small holes.



Figure 10. Bering Straits: bowhead group along ice edge.

Norton Sound Surveys

While based in Nome, surveys of the Norton Sound and of the proposed Norton Sound oil lease area were also conducted, east to west and north to south, respectively. During these flights 118 walruses, 47 belugas, 11 pinnipeds, and 1 bowhead were sighted in or near the proposed lease area. The position of the bowhead was latitude $64^{\circ}09'20''$ N, longitude $165^{\circ}13'00''$ W, which places it just outside of the northern edge of the proposed lease area. This is believed to be the first recorded sighting of a bowhead in the Norton Sound. The whale was approximately 11 m (36 ft) long and was heading to the southeast. At another area near Cape Darby belugas were seen on two occasions, confirming the reports by local pilots of beluga sightings in this area. Gray whales were also observed on 18 May, near the beach west of Nome. Refer to figure 11 and flight 13.

Surveys of St Lawrence Island

Efforts to survey the St Lawrence Island area were not successful due to extremely low ground fog and generally poor visibility. One flight was attempted, flying from Nome to East Cape and then west following St. Lawrence Island toward the village of Gambel, 3 or 4 km (1.6 to 2.2 nmi) from the shoreline. Two unidentified whales, believed to be grays, and some walruses were sighted before this flight was aborted due to weather conditions. During our stay in Nome, daily pilot reports from local flights to St. Lawrence Island informed us that local conditions around the island were not suitable for survey flights.

NOME TO POINT BARROW

According to our estimation, the northern migration of the bowhead began on 14 May. Therefore we decided to delay our departure for 5 days to allow the migration to proceed northward. We estimated that with a swimming speed of 5.5 km/hr (3 knots), the bowhead could cover the distance of approximately 853 km (460 nmi) from Little Diomede Island northeast to Point Barrow in a straight line in approximately 6 days. Accordingly, we departed from Nome on 20 May, flying toward Barrow along the coastal leads. Enroute, small polynyas, cracks, and one huge polynya were seen. From Cape Krusenstern to Point Barrow the nearshore leads were almost continuous. Groups of belugas were the only whales seen until Icy Cape, where seven bowheads were sighted heading northeast.

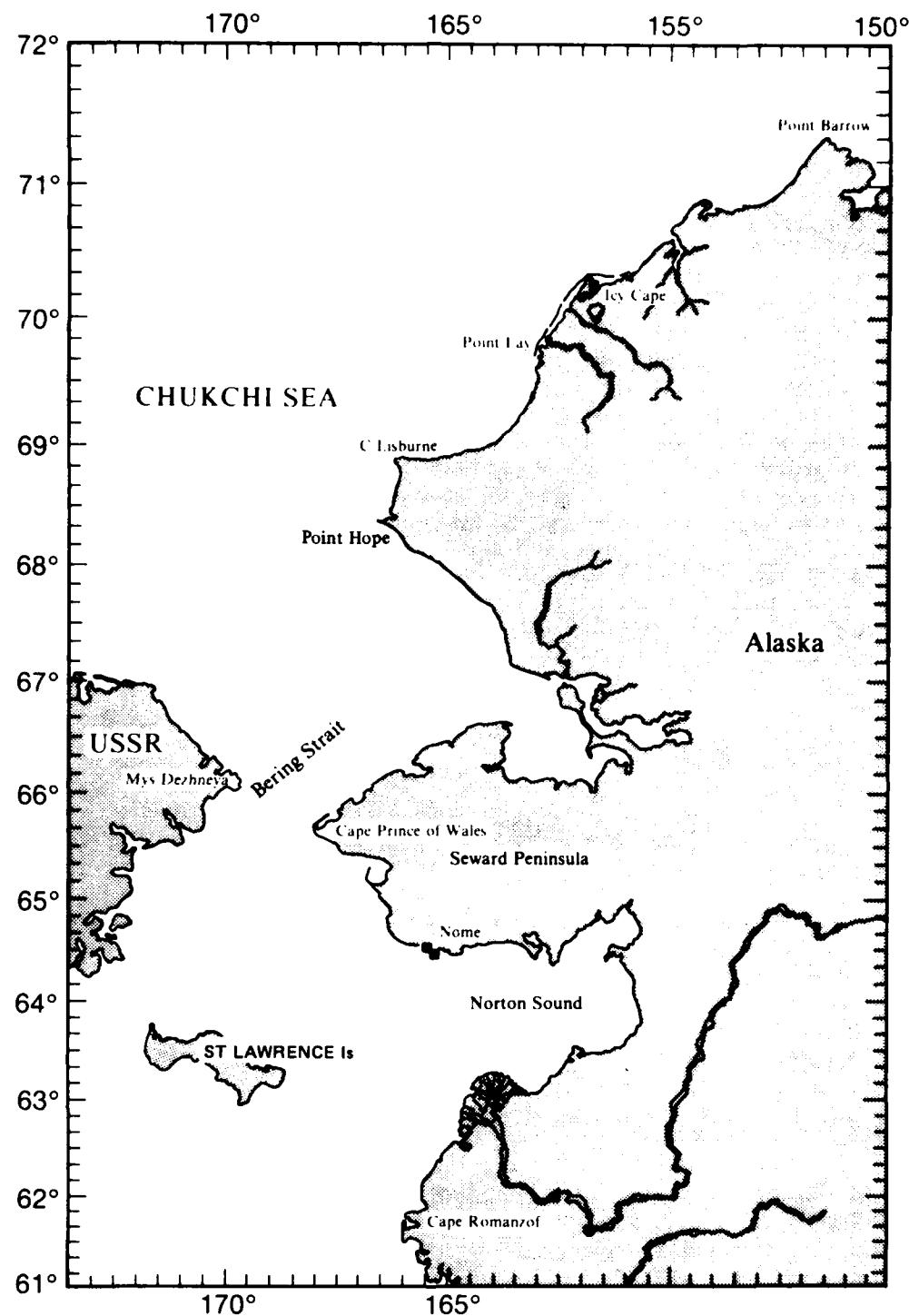


Figure 11. Gray whale sightings near Nome in May.

Surveys of Barrow Area

Because the main migration still had not arrived at Point Barrow on the morning of 22 May, flight 16 headed south along the west edge of the nearshore lead in anticipation of meeting the migration. In an area from approximately 70 km (38 nmi) north to 74 km (40 nmi) south of Wainwright, 33 bowheads and 86 belugas were sighted, all heading to the northeast along the west side of the lead. On the return leg, the shorefast ice was followed 1 km (0.5 nmi) off the ice edge; 13 bowheads and two belugas were seen. These sightings, along with those of the NMFS ice camp, indicated that the major migration around Point Barrow began on 22 May.

Starting on 23 May, all survey efforts were north and east of Point Barrow, in order to follow the migration to the Canadian border. The initial flights were in the vicinity of Point Barrow and to the north, but most sightings were made to the east.

North of Barrow, the ice conditions included open leads with widths of 4 to 5 km (2 to 3 nmi). The nearshore lead 56 km (30 nmi) north of Barrow closed to form a channel approximately 6 km (3 nmi) long and 200 to 300 m (660 to 990 ft) wide, oriented in a northeasterly direction (figure 12). The north end of the channel was completely filled with loose brash ice. The only major visible open water was northwest of the entrance to this channel. No bowheads were sighted in this area, although large concentrations of belugas were seen milling, lying stationary, and heading in random directions. Of particular note is the fact that all bowheads observed approaching the junction between the open water to the northwest and the small ice-filled channel to the northeast chose the latter.

At this time we began to follow the sheer line of the shorefast ice around Point Barrow and to the east. Although large leads were evident in an easterly direction, sightings were rare in these leads. As an example, one lead that was 4 to 6 km (2 to 3 nmi) wide and 30 km (16 nmi) long produced only one sighting, even though we surveyed this lead several times (figure 13). Because of the lack of sightings in the nearshore leads, we returned to Point Barrow and started to fly on the heading which all of the observed whales appeared to be taking, which was due east, or 090° true.

Small cracks and small polynyas could be seen north of the nearshore leads toward the east (figure 14). In these small openings, numerous bowheads were sighted, heading on a course of 090° true. Most of the sightings were of individuals; once we saw a group of four whales. Later flights along other large leads to the east affirmed through a lack of sightings our previous observation that the whales appeared to prefer the more solid ice with small cracks and polynyas to the areas with large leads.



Figure 12. Point Barrow: narrow channel, looking northeast. All observed whales traveled up this channel before heading east.



Figure 13. Beaufort Sea: typical near-shore lead where few whales were sighted; extending east from Point Barrow.



Figure 14. Beaufort Sea: typical ice conditions where most whales were sighted; extending east from Point Barrow to the Canadian border.

When following coastal leads resulted in no sightings for several kilometers, we flew north toward the more solid ice, then turned due east between latitude $71^{\circ}20'00''$ N, and averaging $72^{\circ}40'00''$ N. By flying east on a course of 090° true from polynya to polynya, sightings became routine.

POINT BARROW TO DEADHORSE

On 28 May, flight 20, the base of operations was moved from Point Barrow to Deadhorse. En route, we made a survey flight north of the shorefast ice between latitude $71^{\circ}20'00''$ N and $71^{\circ}40'00''$ N on a course of 090° true. Numerous bowheads were seen on this flight in small leads and polynyas. Several groups of belugas were also seen, for the first time on an easterly course. At approximately longitude $143^{\circ}00'00''$ W (east of Deadhorse), the ice coverage decreased from an estimated $7/10$ to $9/10$, to a $6/10$; large areas of open water were visible from 020° to 180° true when looking east. On our return to Deadhorse from the east, the shore leads along the fast ice were also surveyed. Open water extended from Barter Island to 20 km (11 nmi) east of Flaxman Island, which is located on the eastern edge of the Joint State-Federal lease area. The eastern portion of the lease area was surveyed east to west and was completely ice covered.

Surveys from Deadhorse and to the East

Because the majority of sightings to date were between latitude $71^{\circ}20'00''$ N and $72^{\circ}00'00''$ N, we modified our survey method, and began flying mainly north-south transects between these coordinates. The major effort was now from longitude $153^{\circ}00'00''$ W to $141^{\circ}00'00''$ W. Ice coverage was generally 8/10 to 9/10 with some leads, fractures, and polynyas. Of the bowheads sighted, most were basically black with the typical white chin patch. Some also had white patches on the tail stock and/or the flukes. Some other whales sighted had a white head and were brown in color. These whales are described in detail under WHALES WITH UNUSUAL COLORATIONS and are referred to as unidentified whales.

On the way to and from the selected survey sites, portions of the lease area were traversed and ice coverage was assessed. Thirteen flights passed through parts of the lease area, six flew the perimeter, and three were transects over the lease area. These flights further verified total ice coverage of the Joint State-Federal and proposed Federal Sale 71 lease areas.

For the most part, both lease areas were icebound. Transects were flown early in the beginning of the spring surveys to get a general picture of ice conditions. Then, until the ice began breaking up, flights were made periodically around the perimeter or through the center to retain a general assessment of the conditions.

OVERALL SIGHTINGS

Figure 15 shows the 182 sightings of 262 bowheads made from Point Barrow to the Canadian border. The most easterly sighting was at latitude $71^{\circ}28'00''$ N, longitude $141^{\circ}18'00''$ W, and the last sightings were on 27 June, at latitude $71^{\circ}36'14''$ N, longitude $146^{\circ}05'30''$ W.

NATURAL IDENTIFICATION MARKINGS

Distinctive body markings were observed on many whales in the Bering Straits. These markings were generally on the flukes or on the tail stock. The white colorations varied in size, in some cases covering as much as one-third of the flukes; the white markings were normally located in the central portion of the fluke toward the tail stock, equally distributed on both sides of the center line. Some examples are shown in figure 16. Other white body markings were noted near the head and along the back. These markings were generally small round white patches randomly distributed, and sometimes included possible ice scars (figure 17).

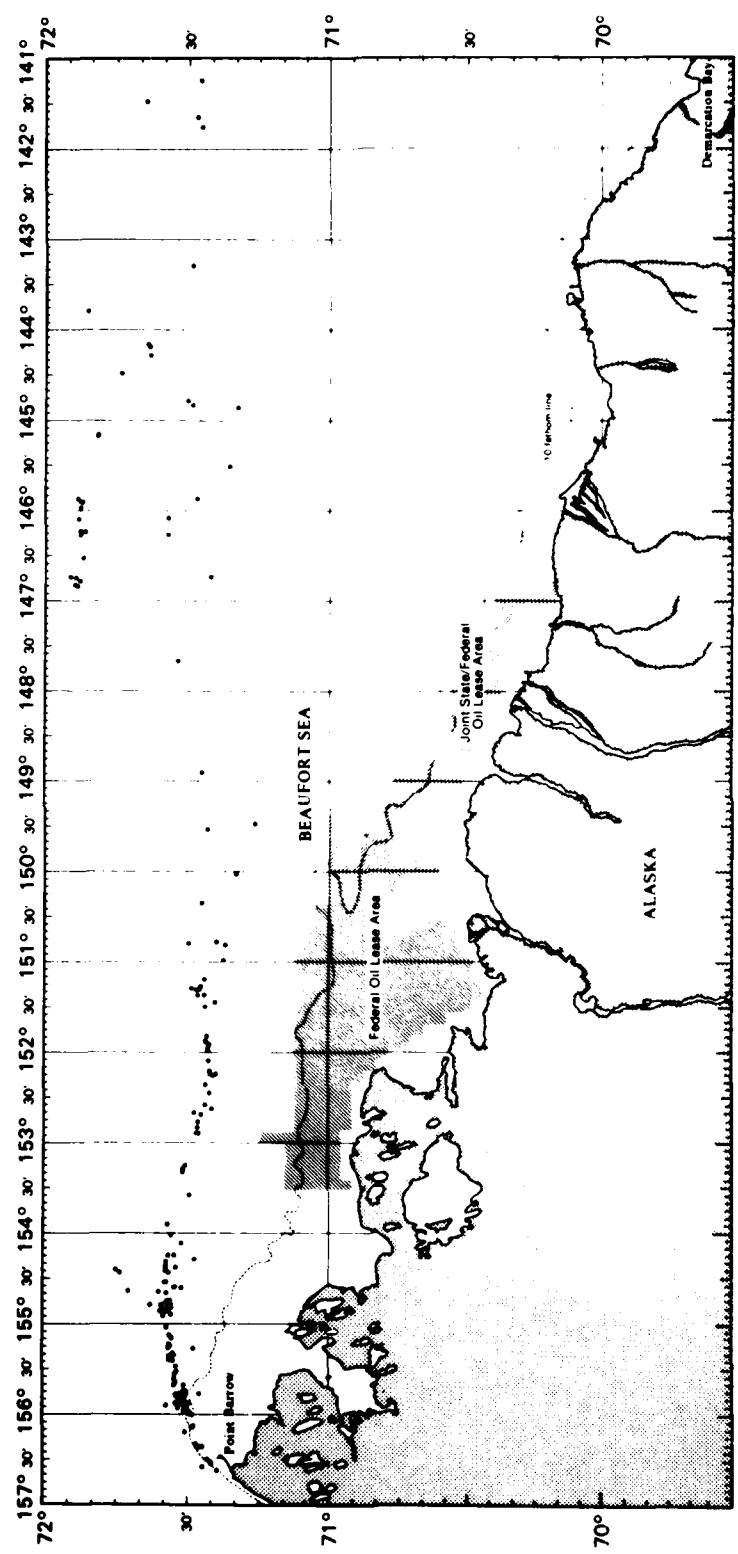


Figure 15. Bowhead sighting chart for May and June 1980.

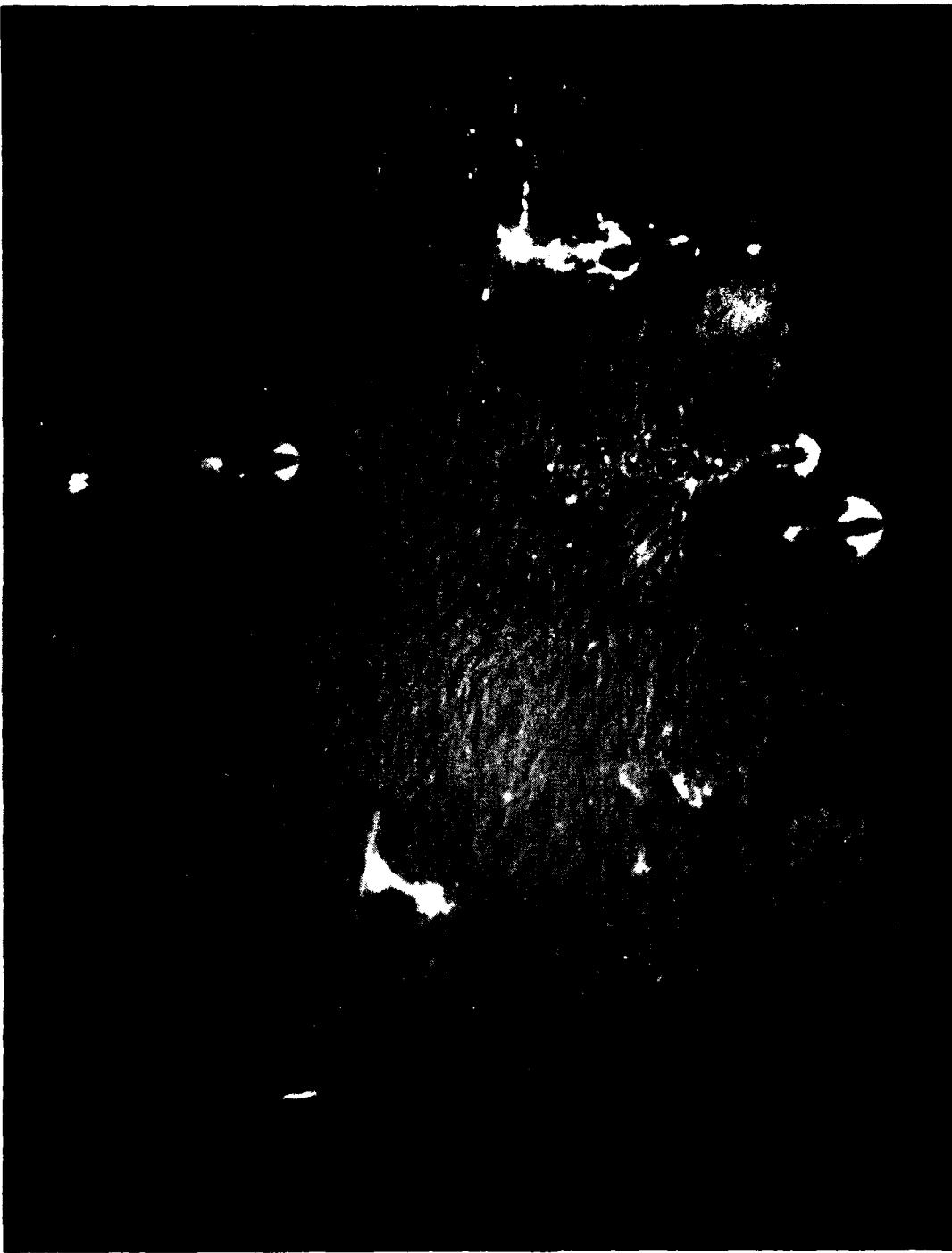


Figure 16. Distinctive bowhead markings; seen in a group, at the extreme top left and right.



Figure 17. Distinctive bowhead marking; suspected ice scar.

WHALES WITH UNUSUAL COLORATIONS

Twenty-six sightings of unidentified whales were made between 23 and 30 May near Point Barrow and to the east. These whales were distinctly different from the bowheads with which they were, in most cases, closely associated. These unidentified whales were light to dark brown, with white coloration on the head. This light coloration extended from the nose at least one-third of the way back on the head, and in a few instances encompassed the entire head, giving them a hooded appearance. They were in most cases longer than bowheads, and their girth was estimated to be at least one-fourth greater than that of bowheads.

Photographs of this whale by itself and in the company of a normal bowhead are shown in figures 18 through 21. Although bowheads usually reacted to the aircraft, these unidentified whales were quicker to submerge. As a result they are just below the surface in nearly all photographs obtained. Speculations as to the identity of this whale vary, and are presented in the DISCUSSION section.

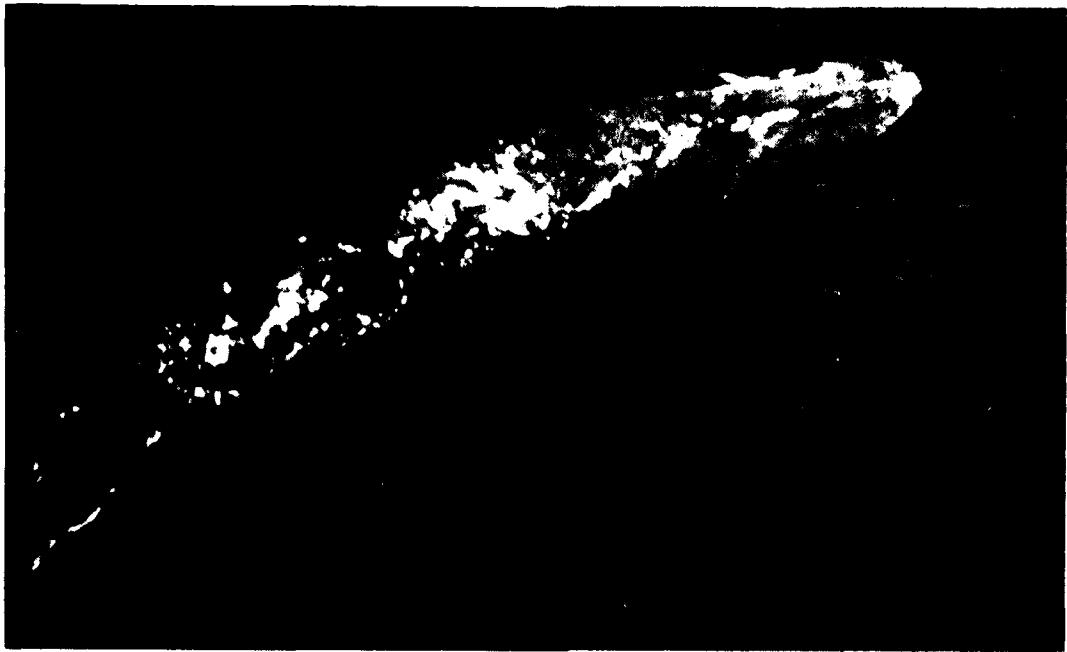


Figure 18. Unidentified whale: overall brown coloration with gray-white head.



Figure 19. Unidentified whale (lower right) and a typically colored bowhead (upper left). Compare distinctive coloration and size differences.

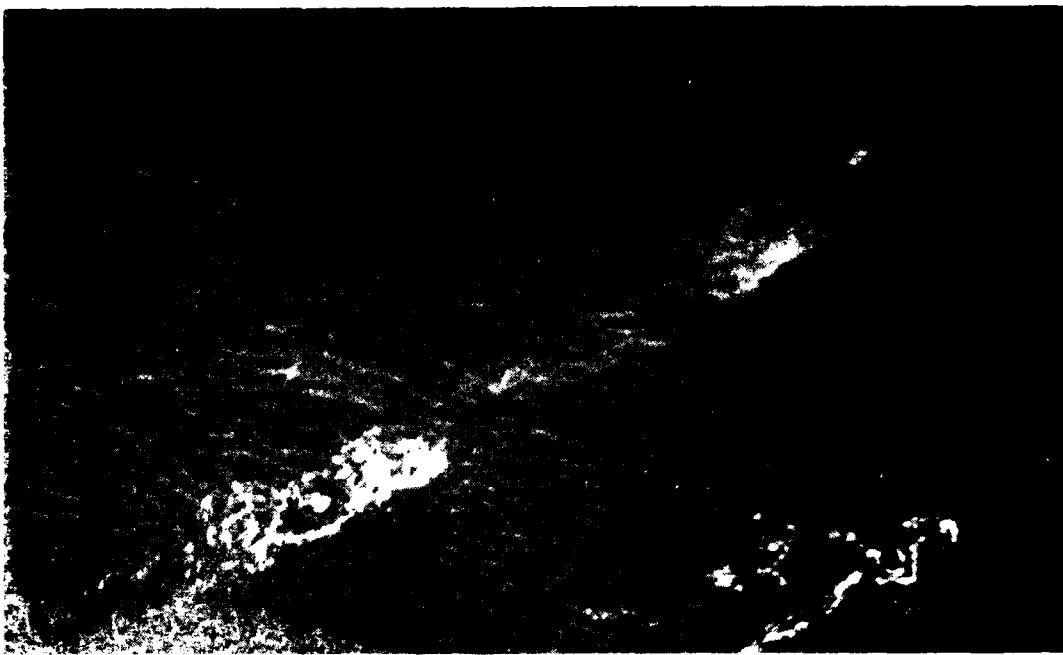


Figure 20. Typical unidentified whale marking: brown with gray-white head.

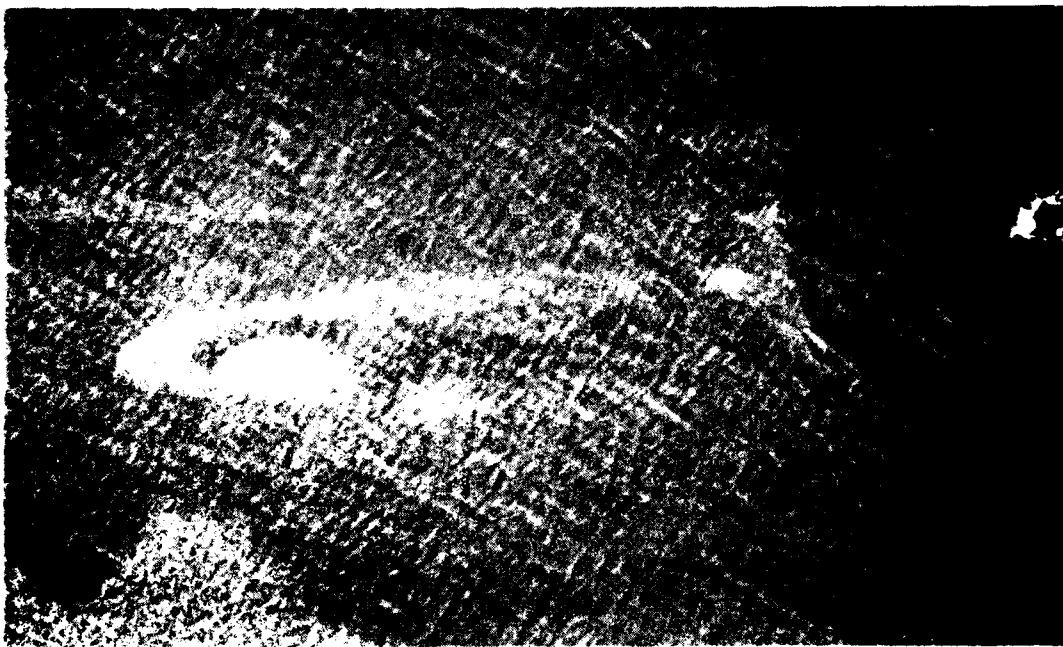


Figure 21. Unidentified whale: brown with distinct white markings on jaw, flipper, and tail.

COW-CALF SIGHTINGS

Only four calves were seen in the spring: one in the Bering Straits, two near Fairway Rock (south of Little Diomede Island), and one near the shorefast ice adjacent to Port Clarence (between Nome and Cape Prince of Wales). Overall size estimates were 5 to 6 m (16 to 20 ft).

ESKIMO WHALING

A 14- to 15-m (46- to 49-ft) whale was sighted on 29 April near Little Diomede Island. It was bleeding profusely, from a cut approximately 50 cm (20 in) long in the middle of the back, running longitudinally down the center of the body. This whale reacted immediately to the aircraft by diving, and efforts to resight and obtain photographs were unsuccessful. Reports later stated that the villagers of Little Diomede had struck a whale on 27 April. It is possible that this was the same whale.

On 8 May several bowheads were sighted by the villagers of Shaktoolik, located on the southeast end of Norton Sound. One of these, a whale 10 m (33 ft) in length, was taken in a chase that lasted approximately 5 hours. It then took several more hours to tow this whale back to the village. This whale was taken the day after we sighted one individual at latitude $69^{\circ}09'20''$ N, longitude $165^{\circ}13'00''$ W in the Norton Sound.

ACOUSTICS

Sonobuoys were dropped near large concentrations of whales on most flights in the Bering Straits. The recordings made contained abundant beluga, bearded seal, and bowhead sounds. Few bowhead sounds were of the quality or intensity one would expect, although the sonobuoys were quite close to the whales on many occasions. This has been experienced in the past, and it is still puzzling when one considers the large number of bowheads and the vigorous activity observed at the time of these recordings.

DISCUSSION

The ice blockage in the Chukchi Sea and south to the Bering Straits caused the 1980 spring bowhead migration to be delayed for nearly a month. This delay gave us a unique opportunity to study behavior, group sizes, and distinct individual body markings along the ice edge at the Bering Straits. In addition, we believe that sightings made in other areas such as Port Clarence and the Norton Sound may be directly related to this delay.

Most of the behavior observed in the Bering Straits area appeared to be of a sexual nature. If this interpretation is correct, and the gestation period of Balaena mysticetus is estimated to be 11 months or slightly more (Nishiwaki, 1972), it will be interesting to see if this possible increase in sexual activity will contribute to an increase in the calf count next spring.

In general, the overall activity of the whales seemed to decrease as time passed during the migration delay. At the beginning of our observations on 29 April, many active groups of three to six whales were observed in close association near the ice edge. By the last flight on 13 May, the majority of whales between Little Diomede Island and Cape Prince of Wales were very passive; also, individuals were seen rather than groups, and most were oriented in a northerly direction. In addition, after obtaining permission to fly into Soviet territory, we made several flights west of the Diomede Islands. Behavior seen in this area also ranged from group social activity at the beginning, to mostly passive on the last flight.

We believe the northward migration began on 14 May, based on the difference between the numerous sightings made in the Bering Straits on 13 May, and only two sightings on 15 May. Other observations of bowheads seen on 15 May, all on a northerly heading west of Kotzebue (Howard Braham, pers comm, 1980), also indicate that 14 May was the beginning of the migration. The migration from the Bering Straits to Point Barrow took approximately 8 days (14 May to 22 May). Using the shortest distance of 853 km (460 nmi) from Little Diomede Island to Point Barrow, we estimated a migratory speed of 4.5 km/hr (2.4 knots). We believe that the whales traveled offshore until abeam of Icy Cape, where they turned northeast and followed the coastal leads to Point Barrow.

When the migration began passing Point Barrow on 22 May, our major effort was to follow it east to the Canadian border. We began by following the nearshore leads eastward. Because of the lack of sightings in these leads we returned to Point Barrow and started flying the heading most whales appeared to be taking. This heading was due east, or 090° true. The ice conditions varied from 7/10 to 9/10 coverage. Under these ice conditions, the majority of sightings were made between latitude 71°20'00" N and 71°40'00" N, and from Point Barrow east to longitude 141°00'00" W. As the migration moved east the whales dispersed over a wider area, thus becoming more difficult to find.

The reactions of the whales to the aircraft became more pronounced as the migration moved northward. At the Bering Straits the reaction had been minimal, but near Point Barrow approximately 70% of the whales responded to the aircraft by diving. Past Point Barrow, all whales dove, almost immediately. Two possible stress factors could account for the dramatic changes in behavior as the whales began to turn east.

One is that ice conditions became more restrictive, the other is that hunting pressure increased as the whales approached Point Barrow. After passing Point Barrow the whales seemed to avoid major leads and chose seemingly more restrictive ice areas. This may also be attributed to hunting pressure (since it is natural for any wild animal to show avoidance behavior when hunted), or it may simply be because the whales were taking the shortest route to the eastern Canadian Beaufort Sea, or it may be a combination of both.

Twenty-six unidentified whales were sighted near Point Barrow, often in close association with bowheads. When observed side by side, the differences in color and size between the bowhead and these whales were very apparent. Aural differences in sounds produced were also detected in a recording made when one of these whales, in the company of bowheads, passed near a sonobuoy.

As the coloration and size of these whales were so distinctive, photographs were sent to several marine mammalogists for their opinions as to their identity. Most thought the whales to be color variants of the bowhead. A suggestion that they were right whales seems ruled out not only on the basis of coloration but because a bonnet is lacking.

In the old whaling literature there are numerous allusions to whales that differed in certain respects from "normal" bowheads. For example, Scammon (1874), largely from information he obtained from two other whaling captains, describes a whale known as the "bunchback". This whale had a "sort of hump, present on the top of the 'small', which is situated about 6 feet forward of the flukes, extending along the top of the back 2 or 3 feet, and in some individuals rises in the highest place about 6 inches." Bunchbacks were said by one whaling captain to yield "a very large amount of bone (baleen) in proportion to oil." However, since coloration is not mentioned, the bunchback was presumably similar in that respect to the conventional bowhead.

The Eskimo designation of "[bowhead] whales that are especially fat as Ingutuk if small, and Ingutuvak if large" (Marquette, 1977) also does not describe the hooded brown whales we report, except perhaps with respect to girth.

It is possible that this whale is the one described by Bodfish (1936), who wrote of a "hard to kill unusual whale." "We found that the top of his head was white and that all the [whale] bone was white except for three streaks of purple and brown down the center of each slab."

Clearly, the brown whales warrant further investigation.

SUMMER SURVEYS
(JULY, AUGUST)

DEADHORSE BASE OF OPERATIONS

Surveys of the Beaufort Sea lease areas were continued during the summer period. Our base of operations remained at Deadhorse, Alaska. Detailed information on each survey is shown in flight tracks 39 through 61 in appendix C. Flight hours logged, down time, type of flight, and overall flights completed are listed in table C-1. The total number of sightings and total number of individuals are listed according to species in table 2.

Marine mammal sightings in or near the lease areas during the summer consisted of pinnipeds and two polar bears. The only other significant sighting was that of a stranded bowhead seen on 3 July on Jeanette Island, described in detail under the heading STRANDING.

From mid-July through August, the major flight effort was in support of the bowhead tagging project being conducted in the eastern Canadian Sea. This program was under the direction of Larry Hobbs, National Marine Fisheries Service (NMFS) Northwest and Alaska Fisheries Center, Seattle, Washington. The survey flights covered the area near Tuktoyaktuk, Northwest Territory, Canada, and are described in detail in the NMFS 1980 bowhead tagging project's final report to the BLM (Hobbs, 1980). In flights of transit from Deadhorse to Tuktoyaktuk, six bowheads were seen between Herschel Island and Demarcation Bay on 22 August, 40 km (22 nmi) offshore. Two of these whales were widely separated and some distance from the remaining four, who were bunched together in a tight group with physical contact and suspected sexual activity.

Periodic flights were made over the lease areas, in addition to coastal flights ranging from Nome to Deadhorse, searching for stranded whales. The only significant sightings made were on one coastal flight from Nome to Point Barrow in July after radio modifications for the tagging project had been made in Anchorage. Unidentified whales were sighted in the northern Bering Sea, and gray whales were observed apparently feeding along the coast of the Chukchi Sea from Point Hope to Point Barrow (refer to figure 22 and flight 47 for details).

ICE CONDITIONS

In mid-July the ice coverage north of the Barrier Islands varied from open water with some floes to ice coverage estimated to be 7/10 to 9/10. By late August brash ice was constantly present 8 to 16 km (4 to 9 nmi) north of Harrison Bay and 56 to 93 km (30 to 50 nmi) offshore at

Table 2. Summer marine mammal sightings

Species	Total Sightings*	Total Individuals*
Bowhead Whale <u>Balaena mysticetus</u>	229	685
Beluga Whale <u>Delphinapterus leucas</u>	44	599
Gray Whale <u>Eschrichtius robustus</u>	13	50
Ring Seal <u>Phoca hispida</u>	40	206
Bearded Seal <u>Erignathus barbatus</u>	5	7
Polar Bear <u>Ursus maritimus</u>	6	8
Walrus** <u>Odobenus rosmarus</u>	5	5

*All counts include possible resightings.

**Partial count.

Prudhoe Bay; it consisted of loose ice chunks and variously sized sections of pack ice which showed extensive melt-puddling on the surface. The coverage of open water by loose ice changed continually due to wind and water currents. However, there were large patches of loose ice of at least 4/10 coverage present at all times. Occasional ice densities of 8/10 to 9/10 coverage were observed from July to August 1980 and became much more common in early September.

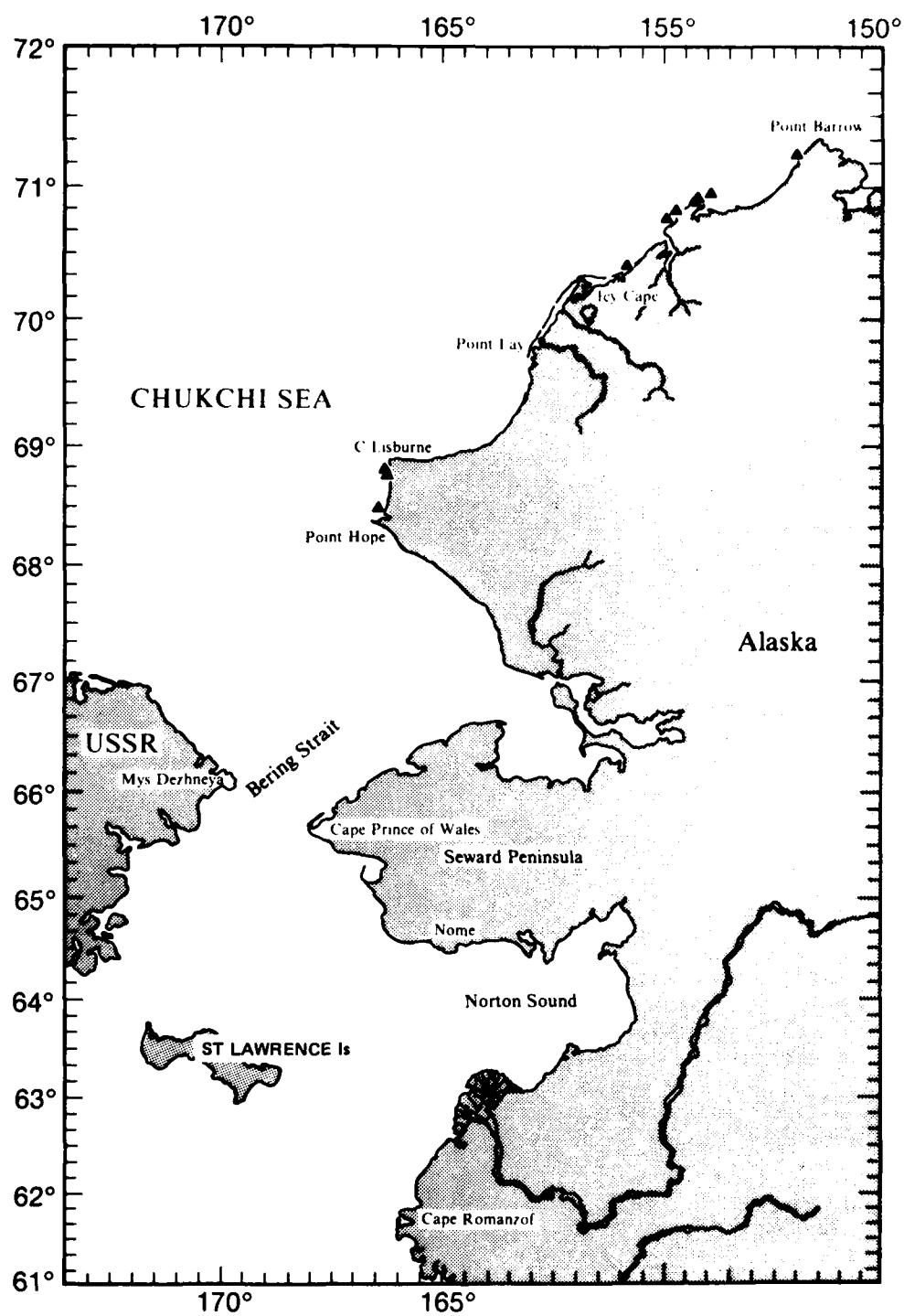


Figure 22. Gray whale sightings from Point Hope to Point Barrow in July.

STRANDING

The only stranding of the summer was first seen on 3 July by ERA helicopter pilots working out of Prudhoe Bay. The stranding occurred on Jeanette Island, which is one of the Barrier Islands and is centrally located in the Joint State-Federal lease area.

On 7 July a trip was made to Jeanette Island to identify, obtain photos, take measurements, collect specimens, and determine cause of death if possible. The stranding was that of a 7.5-m (24.8-ft) bowhead (figure 23). The body was approximately 2 m (6.6 ft) at its widest point. The circumference of the tail stock was 71 cm (28.4 in), the flukes measured 1.29 m (4.3 ft) across, and the distance from the nose to the base of the skull was 1.87 m (6.2 ft). Samples of the baleen were collected and measured, the longest being 52 cm (20.8 in).

The animal had apparently been deposited on the island by the ice. It was evident that bears had been feeding on the carcass. In addition, someone had examined the whale before us and had cut out a 15- to 20-cm (6- to 8-in) section of baleen from the right side.

The cause of death was not determined, due to the decayed state. Sex and other characteristics could not be determined. Flights made in October 1979 passed near the site on several occasions and no stranding was seen. We believe this places the time of stranding between November 1979 and July 1980. The whale was probably brought in by the sea ice.



Figure 23. Stranded 7.5-m bowhead, Jeanette Island (latitude 70°21'01" N, longitude 147°23'05" W)

DISCUSSION

The main effort in the summer was to support the bowhead radio tagging project in the eastern Canadian Beaufort Sea. Several surveys were also made of the Beaufort Sea lease areas; no bowheads were seen, with the exception of the stranding on Jeanette Island.

The final sighting of the summer was of six bowheads in Canadian water west of Herschel Island on 22 August. We believe this was an indication that the fall migration might start earlier than the 1979 migration of late September.

FALL SURVEYS
(SEPTEMBER, OCTOBER, NOVEMBER)

DEADHORSE/NOME BASES OF OPERATIONS

In September and October the base of operations was at Deadhorse, Alaska. The main survey effort was of the area that included the Joint State-Federal and Federal Sale 71 Beaufort Sea lease areas. Other flights were made east to the Canadian Beaufort in support of the tagging project, and also to the Beaufort Lagoon in support of the food study project. Detailed information for each survey is shown in flight tracks 61 through 97 in appendix C.

On 25 October the base of operations was moved to Nome due to a lack of sightings in the Beaufort Sea over the previous 14 days. En route to Nome no sightings were made other than of pinnipeds. Surveys of the Bering Straits, northern Bering Sea, and Chukchi Sea were completed from Nome, but only groups of gray whales, apparently feeding in large clouds of muddy water, were seen (figure 24). Surveys of the proposed Norton Sound lease area produced no sightings. Refer to flights 98 through 106 for details.

Table C-1 lists flight hours logged, down time due to weather or aircraft maintenance problems, overall flights completed, and flights other than oil lease surveys; or when in transit or in support of other projects. The total number of sightings and total number of individuals are listed according to species in table 3.

ICE CONDITIONS

The ice conditions in early September were estimated to be 5/10 to 7/10 coverage 14 km (8 nmi) north of the Barrier Islands. The lease areas were estimated to be 7/10 grease and floe ice. The only consistently open water was north of the Barrier Islands near the 20-m (10-fathom) contour line (figure 25). These conditions changed rapidly and by 16 September freeze-up began. By 24 September all workboats had been removed from the water, because the ice conditions made navigation impossible.

In areas of study such as Harrison Bay, Smith Bay, and east along the Barrier Islands, the ice conditions remained basically the same throughout the remainder of the study period, with ice coverage estimated at 7/10 to 9/10 in and about the lease areas (figure 26).

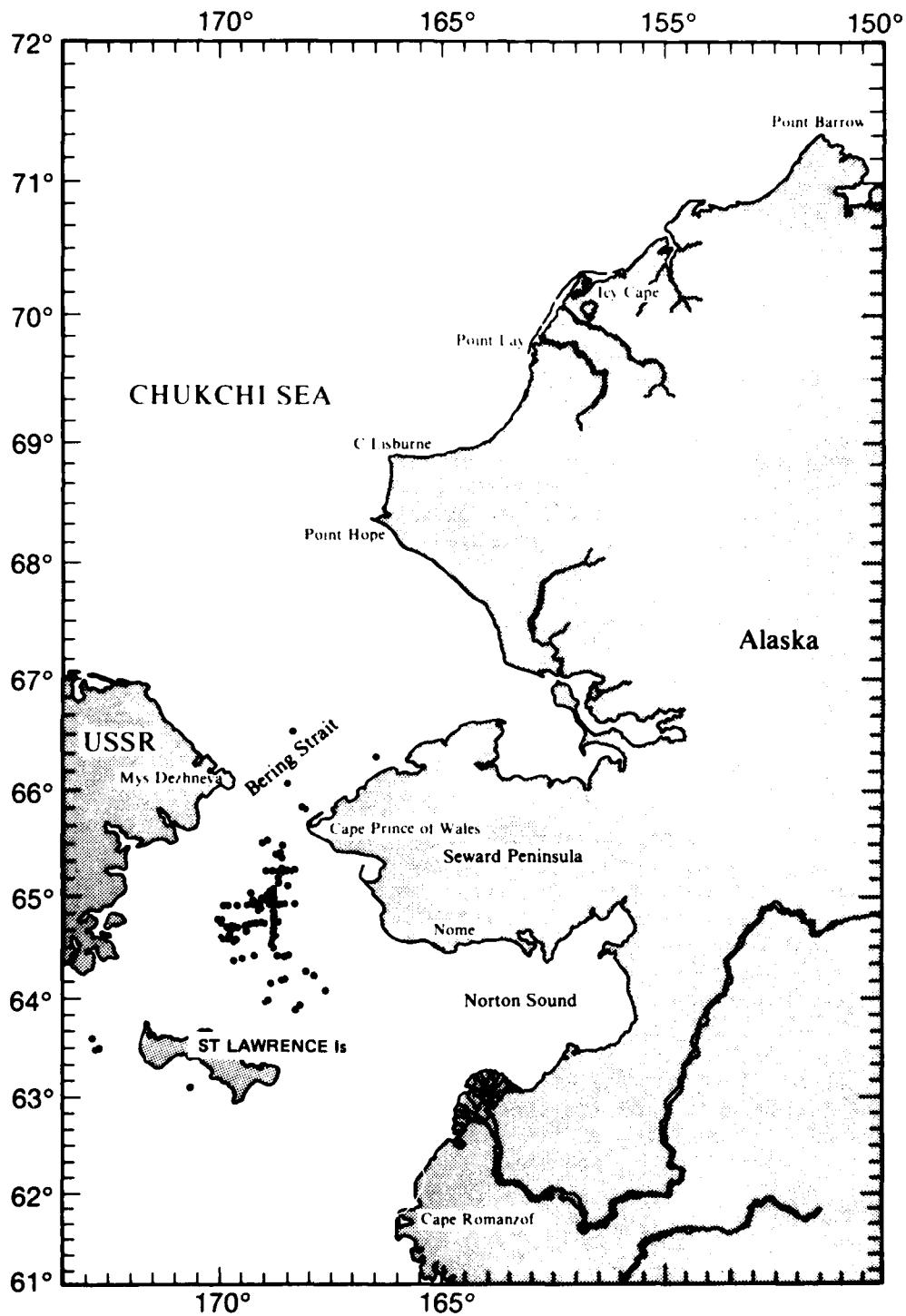


Figure 24. Gray whale sightings in the northern Bering Straits and Chukchi Sea in October and November.

Table 3. Fall marine mammal sightings

Species	Total Sightings*	Total Individuals*
Bowhead Whale <u>Balaena mysticetus</u>	36	49
Beluga Whale <u>Delphinapterus leucas</u>	4	5
Gray Whale <u>Eschrichtius robustus</u>	110	271
Ring Seal <u>Phoca hispida</u>	10	27
Bearded Seal <u>Erignathus barbatus</u>	10	21
Polar Bear <u>Ursus maritimus</u>	21	39
Walrus <u>Odobenus rosmarus</u>	0	0

*All counts include possible resightings.

Flights to the pack ice were made, but no sightings were noted. The approximate position of the pack ice edge during September and October was latitude 71°30'00" N.

SIGHTINGS BY OUR SURVEY TEAM

The first sightings for the fall season were on 9 September at latitude 71°25'00" N, longitude 147°25'00" W. Two bowheads were seen from Jeanette Island, centrally located in the Joint State-Federal lease area. They were heading west, approximately 1 km (0.6 nmi) offshore.

Between 9 September and 9 October intermittent sightings were made between the Canadian border and Smith Bay, including the Joint State-Federal and proposed Federal Sale 71 lease areas. Most sightings were



Figure 25. Beaufort Sea: typical fall ice conditions and open water along 10-fathom (20-meter) curve.



Figure 26. Joint State-Federal Lease Area: typical fall ice conditions.

of individual whales, although one group of four was seen; sightings were generally made in ice conditions as shown in figure 27. Two bowheads were sighted inside the Joint State-Federal lease area, and one was seen in the proposed Federal Sale 71 lease area.

The peak sighting day was 25 September, when eight bowheads were seen north of the Joint State-Federal lease area. The final sighting of the season was of a cow accompanied by a calf on 9 October, northwest of Harrison Bay at latitude $71^{\circ}16'00''$ N, longitude $157^{\circ}04'12''$ W. Both whales were lying still in a small polynya when sighted (figure 28).

North-south transects were continued through mid-October, but no further sightings were made after 9 October. Sightings were difficult to make on these surveys due to limited open water. Therefore, the last few flights were made east to west, following open water. It was hoped that the status of the migration could thus be verified. As no further sightings were made, we concluded that the migration was completed, and ended the surveys of the Beaufort Sea on 25 October with a total of 49 bowhead sightings. Figure 29 shows the fall bowhead sightings; figure 30 shows the overall gray whale sightings for 1980.

SIGHTINGS BY OTHERS

Between 15 and 20 September seven bowheads were sighted in the deeper water between Smith Bay and Point Barrow by the Alaska Fish and Game Walrus Survey Team. Some appeared to be feeding, while others were heading southwest. Belugas were also sighted almost continuously offshore and near the pack ice during this period.* A pilot report** contributed the last sighting of the season which was on 17 October. Two bowheads were seen heading west, 5.6 km (3 nmi) north of Challenge Island (located at latitude $70^{\circ}12'0''$ N, longitude $146^{\circ}05'00''$ W).

BEHAVIOR

Suspected feeding behavior was observed east of Barter Island, near Demarcation Bay - Beaufort Lagoon, during mid to late September. The few bowheads observed in this area were nearly all within 3 km (2 nmi) of the beach. The ice coverage was estimated to be 4/10 to 5/10. The whales were heading in random directions and diving periodically; little response to the aircraft was noted in this area. Whales sighted in the study area, which included the oil lease areas, were all heading due west at speeds estimated to be between 2.8 and 5.6 km/hr (1.5 and 3 knots). All of these whales were in estimated ice concentrations of 7/10 to 9/10 and nearly all reacted to the aircraft by diving.

* J Burns, Alaska Fish and Game, Fairbanks, AK, 1980 - Personal communication.

** Bill Noble, Evergreen Helicopters, AK, 1980 - Personal communication.



Figure 27. Typical fall bowhead sighting conditions.



Figure 28. Beaufort Sea: cow with distinctive marking and calf, October 1980.

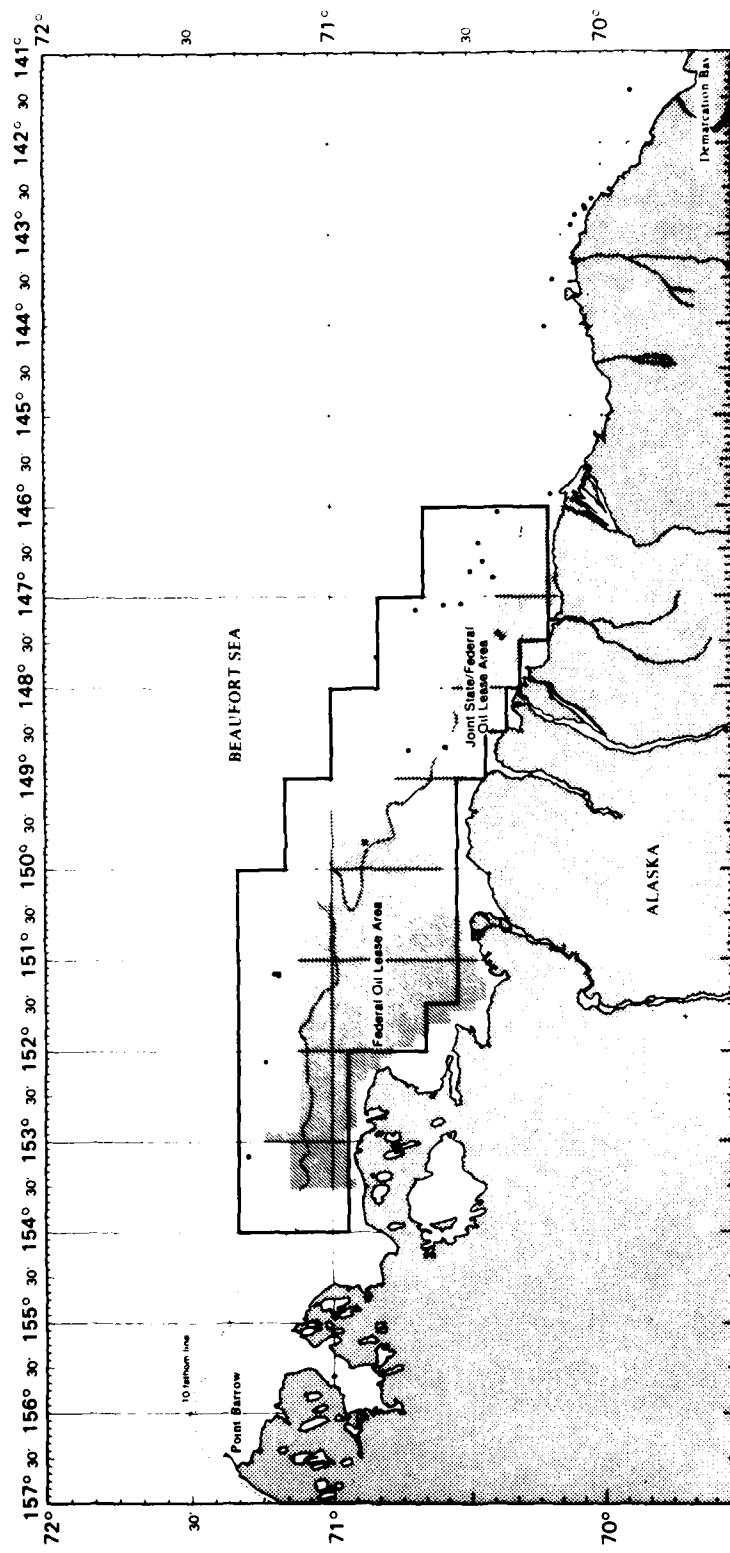


Figure 29. Bowhead sighting chart for September and October 1980. The primary study area is outlined and includes the Joint State-Federal and Federal Sale 71 lease areas.

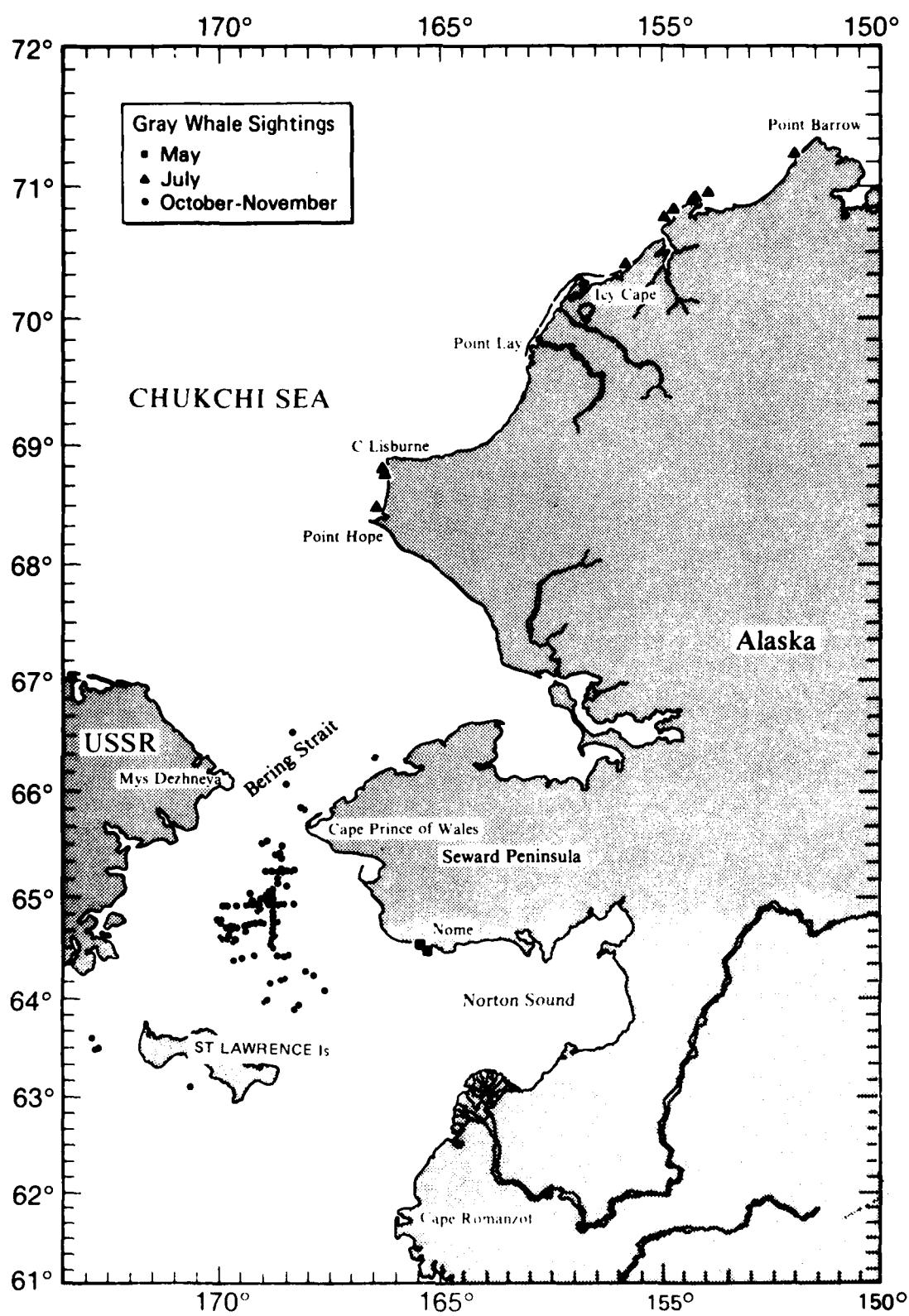


Figure 30. Overall gray whale distribution in 1980.

DISTINCTIVE BODY MARKINGS

Three bowheads seen in the fall had white markings on their flukes similar to those described in the spring. Of these, one was a cow with a calf (figure 28). The cow had a white triangle in the center of the flukes. She was estimated to be 13 m (43 ft) in length and the calf was estimated to have a length of 3.5 to 4.5 m (11.6 to 14.9 ft).

UNUSUAL COLORATIONS

Three unidentified whales with unique body colorations were seen during the fall surveys. Their sizes were estimated to be 13 to 15 m (43 to 50 ft). One was seen north of Beaufort Lagoon and appeared to be feeding. Two were north of the Joint State-Federal lease area and were heading due west. All were brown in color, with a grayish white coloration on their heads. Reactions to the aircraft were not as pronounced as those seen during the spring.

ESKIMO WHALING

On 14 September (flight 68), en route to the Beaufort Lagoon, five whales were seen near the shore and east of Barter Island. On our return trip the whalers of Kaktovik had taken a bowhead in the general area of the earlier sightings. This bowhead was estimated to be 12 m (40 ft) in length.

ACOUSTICS

Sonobuoys were dropped randomly during the surveys. On only two occasions were bowhead sounds recorded during this period. The first was on 20 September during a Joint State-Federal lease area survey. At latitude $70^{\circ}32'00''$ N, longitude $146^{\circ}59'30''$ W sounds were heard for a period of 3 minutes. One bowhead was seen at latitude $70^{\circ}43'20''$ N, longitude $148^{\circ}14'05''$ W during this survey.

The best sounds recorded were on 25 September, which was also our peak day for sightings. The sonobuoy was dropped at latitude $70^{\circ}29'00''$ N, longitude $145^{\circ}08'00''$ W near two bowheads. Throughout this survey of the Joint State-Federal lease area, continuous sound productions were monitored and recorded.

The sounds recorded in 1980 are now being analyzed. The results will be presented in the NOSC report to the BLM for the 1981 season.

DENSITY ESTIMATE

The 1980 bowhead density estimate was derived using the computer program TRANSECT (Burnham *et al.*, 1980). This program evaluates aerial survey data with respect to the assumptions and parameters of line transect density estimators. The estimate was calculated for the study area shown in figure 29, and includes the Joint State-Federal and Federal Sale 71 lease areas.

Migrating bowheads were sighted in fall 1980 from 9 September to 9 October. The period for which the estimate is calculated is 20 September to 9 October, since flights made during this period satisfy the assumptions of line transect estimation. The peak bowhead count occurred on 24 September when six whales were sighted while a survey of the area was being conducted. Sightings on all other dates were of individual bowheads and occasionally of pairs of them.

The calculated density estimate is that 15 whales may be present in the study area at any given time during the 20 September through 9 October period. The confidence limits for this estimate are 12 to 17 whales ($\rho = 0.05$).

To estimate the total number of whales that migrated through the study area, several factors besides density must be determined: the area, the period of migration, and the migratory rate through the study area. The study area was measured to be 17,700 km² (5200 nmi²) and the migration period, as previously noted was 20 September through 9 October. The swimming speed was estimated to be 4.6 km/hr (2.5 knots). The most probable distance migrated was arbitrarily set at 295 km (159 nmi), so that the migratory rate through the study area was estimated at 2.7 days; that is, the average time a whale spent in the study area was 2.7 days. Using these parameters, the estimated number of whales that migrated through the study area was 107.

No direct comparison was made between the 1980 density estimate and the revised 1979 estimate (17 whales; 95% confidence interval of 14 to 21 whales) because there were extreme differences in ice coverage between the 2 years. Also, in 1980 the study area was expanded to include both the Joint State-Federal and Federal Sale 71 lease areas. However, overall bowhead distribution was compared for 1979 and 1980, as shown in figure 31. This distribution was confined in both 1979 and 1980 to the coastal zone of the Beaufort Sea where most of the surveys were flown. The most significant feature of this nearshore distribution is that the majority of sightings were near the 20-m (10-fathom) contour line. Offshore areas farther north were surveyed, but not to the extent required to determine distribution.

* A detailed discussion concerning the methods used to derive a density estimate will be provided in an independent paper currently being prepared.

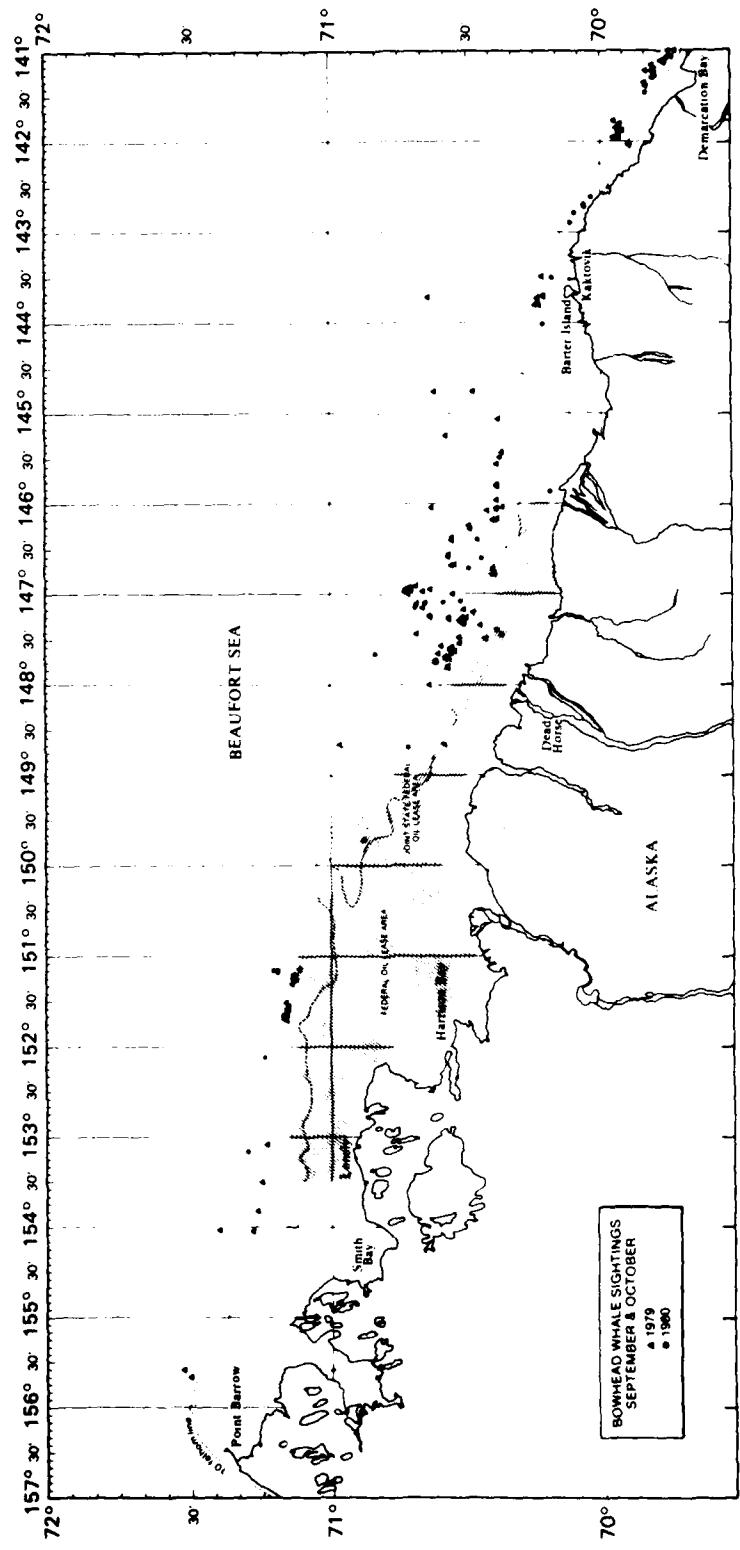


Figure 31. Combined distribution of bowheads for the falls of 1979 and 1980.

DISCUSSION

Ice conditions seemed to be a major factor affecting the behavior of the whales in their migration through the Beaufort Sea study area and our ability to sight them, as indicated by the differences in data between 1979 and 1980. In 1979 there was very little or no ice present until October, the migration lasted approximately from 24 September to 20 October, and 249 bowheads were seen moving very slowly toward the west with random headings and suspected feeding behavior. We feel now that this count was probably high due to possible resightings of whales over a period of days since they were migrating so slowly. However, in 1980, the ice conditions were very heavy, possibly contributing to an earlier migration. Overall, 49 bowheads were seen with the peak count on 25 September in the survey area (figure 29).

This low count may be attributed to three factors: the increased speed of the whales (2.8 to 5.6 km/hr), their diving reaction in response to the aircraft, and the heavy ice conditions which made sightings difficult. Most north-south transects were primarily over solid ice so that sightings were restricted to small areas of open water that were observed on each leg of the transect.

The number of sightings might have been greater had we followed the small leads from east to west during the migration. We refrained from using this method until the final days of the survey period in the hopes of obtaining a good comparison of data for the past 2 years.

Surveys show that in the Chukchi and Bering Seas in early November - after it was known that the whales had passed the Beaufort Sea study area - no bowhead sightings were recorded. This raises the question of "where did the whales go?"

CONCLUSIONS

The following conclusions were made concerning the spring, summer, and fall 1980 bowhead whale study.

- a. The northern migration of the bowhead began on 14 May, about a month later than that of 1979, due to icebound conditions in the Bering Straits and Chukchi Sea. A bowhead sighting in Norton Sound may be directly related to this delay.
- b. While waiting for the ice to break up in the Bering Straits in the spring, the predominant bowhead behavior seemed to be that of mating. Activity decreased with time during the migration delay.
- c. During the spring migration from Pt. Barrow eastward, bowheads appeared to prefer the solid ice with small cracks and polynyas to areas with large leads. The migration east from Pt. Barrow and north of the lease areas peaked on 24 and 25 May.
- d. Both Beaufort Sea oil lease areas were icebound in the spring. No mammals were observed in the area.
- e. Bowhead reaction to aircraft became more pronounced past Pt. Barrow during the spring migration; whales generally dove immediately.
- f. Twenty-six large brown unidentified whales were noted in late May in the company of normal-morph bowheads. These sightings call into question morphology parameters of the bowhead species.
- g. No bowheads were sighted in the Beaufort Sea lease areas in the summer.
- h. During the fall migration, it was estimated that bowheads were traveling between 2.8 and 5.6 km/hr (1.5 and 3.0 knots) as they went past the lease area. Most whales reacted to the aircraft by diving.
- i. Three bowheads were sighted within Beaufort Sea oil lease areas in the fall. Two whales were sighted from Jeanette Island inside the Joint State-Federal lease area on 9 September. One bowhead was sighted inside the Federal Sale 71 lease area at latitude $70^{\circ}53'06''$ N, longitude $149^{\circ}42'42''$ W on 22 September.
- j. A few bowheads were observed apparently feeding near Demarcation Bay within 3.7 km (2 nmi) of the beach during mid-September.

- k. The fall bowhead migration peaked on 25 September and was over by 25 October.
- l. No bowheads were sighted during surveys of the Bering and Chukchi Seas in early November leaving open the question of where they go at migration end.

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APPENDIX A

* SHORT HISTORY OF THE BOWHEAD WHALE, Balaena mysticetus (Ljungblad, 1980)

Bowhead whales, Balaena mysticetus, Linnaeus 1758 (also referred to in the literature as Greenland whale, Arctic right whale, and great polar whale) are large baleen whales found circumpolar in the Arctic. Five separate stocks are thought to exist in the Sea of Okhotsk; the Bering, Chukchi, and Beaufort Seas; Baffin Bay, Davis Strait, and their adjacent waters; Hudson Bay; and the Greenland and Barents Seas. The last-mentioned stock is very near extinction. The Hudson Bay and Sea of Okhotsk stocks may be stable but at relict levels of abundance (100 or less). In Baffin Bay and Davis Strait there are at least a few hundred left, and they may be increasing slowly. The only substantial population is that in the Bering, Chukchi, and Beaufort Seas.

Commercial exploitation of this population began in the Bering, Chukchi, and later Beaufort Seas during the mid-1800s. The last reported voyage occurred in 1916 when the steamer HERMAN and the auxiliary whaling schooner BELVEDERE sailed north in the spring from San Francisco and Seattle, respectively, returning that autumn with some whale products. Some of the Arctic Alaskan trading companies continued to deal in whalebone for a few more years into the early 1920s. Bowheads have been completely protected from commercial whaling by the International Convention for the Regulation of Whaling since 1946 and, subsequently, by the US Marine Mammal Protection Act (MMPA) of 1972 and the US Endangered Species Act (ESA) of 1973. However, aboriginal whaling continues at a level which has been increasing in recent years. The annual harvest is the subject of much debate and legal conflicts between Eskimos and individuals or institutions attempting to stop or regulate this whaling.

Though once much more abundant (perhaps from 18 000 to 36 000 in 1842) and more wide-ranging (with catches as far southeast as the Pribilof Islands), the estimated 1000 to 3000 remaining bowheads in the Western Arctic population apparently winter in the southwestern Bering Sea along and south of the pack ice edge and in polynyas within the ice.

In early spring, whales from this population move northward from the Bering Sea, passing St Lawrence and Diomede Islands, primarily on their western sides, in three or four pulses or waves of abundance. Most turn northeastward in the Chukchi Sea following the most inshore leads or cracks in the ice, round Point Barrow in April, and continue along the leads to Banks Island and Prince Albert Island. As the ice recedes in summer, they spread south and east, at least as far as Amundsen Gulf. As ice begins to re-form and advance in the fall, they move westward (most apparently moving close outside the 10-fathom line

and/or along the ice edge), some reaching the northeast Soviet coast near Wrangel Island before yielding to the winter ice by moving gradually southward to favored wintering grounds.

The migratory behavior of bowheads seems to depend entirely on ice formation and movement. They are not gregarious, and usually travel alone or in small groups. Concentrations of up to 50 whales have been reported on suspected feeding grounds. Whaling records suggest also that bowheads are segregated to some extent by age and sex during migrations.

The bowhead is a slow-moving whale (average speed of 3 km/hr or less). It reportedly can remain underwater for periods of over 40 minutes, but is not regarded as a deep diver. Traveling bowheads often raise their flukes on the last dive of a series. Bowheads have been observed to hang vertically in the water with their heads exposed. Tail-lobbing and flipper-slapping are seen occasionally.

The bowhead's life history is poorly understood. Females probably calve at intervals of at least 2 years, and calves are reportedly born in the spring. Calves have been seen in May in the Bering Sea and in October in the Beaufort Sea. The percentage of calves observed to date is low, between 1 and 2% of the total population. Bowheads feed primarily on swarms of small- to medium-sized zooplankton euphausiids, amphipods, copepods, mysids, and pteropods. While basically "skimmers," they do forage very near the bottom, at least in shallow areas, and have been seen surfacing at the edge of a mud boil of their own making with mud and detritus streaming from their mouths.

The only suspected natural predator is the killer whale. Starvation from lack of access to feeding areas and suffocation under ice are other suspected natural causes of death.

APPENDIX B

UNDERWATER SOUNDS RECORDED FROM MIGRATING BOWHEAD WHALES, Balaena Mysticetus, IN 1979

DONALD K. LJUNGBIAD and PAUL O. THOMPSON

ABSTRACT. Bowhead whale sounds were recorded in the course of conducting aerial surveys of the Beaufort Sea during spring and fall migrations in 1979. Sounds were recorded over a 4 week spring, and 12 day fall collection effort. Most bowhead sounds in both spring and fall samples were low frequency (to 800 Hz) moans presented here in two classes: simple and complex. Repetitive moan sequences were found in the spring sample and are discussed here as simple songs. No such repetitive sequences were found in fall recordings. Unique to fall recordings were high frequency (to 4 kHz) screeches or trumpeting calls. Estimates of number of whales from sound production is discussed. No particular behavior nor determining condition was associated with bowhead sound production.

INTRODUCTION

The bowhead whale, Balaena mysticetus, inhabits the Bering, Chukchi, and Beaufort Seas. This whale is listed as both "endangered" under the Endangered Species Act and "depleted" under the Marine Mammal Protection Act.

Bowheads migrate annually from the Bering Sea in the spring (April, May, and early June) north into the Beaufort Sea and east into the Mackenzie Delta - Banks Island area in Canadian waters.

In early or mid-September, a westerly return migration begins from the Banks Island - Mackenzie Delta area to Point Barrow, and south again to the Bering Sea.

This migration passes near areas currently being assessed for their oil resources. There is concern that resource-related development may affect whales that inhabit these areas.

In 1979, under the auspices of the Bureau of Land Management, the Naval Ocean Systems Center (NOSC) undertook a study to determine if the migratory path of the bowhead passes near or through the proposed Beaufort Sea oil lease area. Data on the sound production of bowheads were sought as possible tools in detecting their presence and assessing population size.

Aldrich (1889) described sounds of the bowhead, heard through the hull of his boat and therefore somewhat modified, as resembling "the hoo-oo-oo of the hoot owl, although longer and drawn out and more of a humming sound than a hoot." He also referred to a slight rise in the pitch in many calls, noting that: "Beginning on F, the tone may rise to G, A, and B, and sometimes to C before sliding back to F again."

Low-frequency sounds were recorded in the presence of an adult bowhead whale and accompanying calf (Ljungblad *et al.*, 1978) during the 1978 spring migration near Point Barrow. The sounds were of two types, identified as "type A" and "type B", and covered frequency ranges of 50 Hz to 580 Hz and 100 Hz to 195 Hz, respectively. Braham *et al.* (1978) recorded sounds in the fall of 1978 that could best be described as an elephant-like roar or trumpeting.

Tape recordings of bowhead sounds were made while conducting aerial surveys of the bowhead population during the spring and fall migrations of 1979. This paper describes the circumstances of recording these sounds and summarizes the basic characteristics of the sounds.

METHODS

Aerial surveys were conducted in the vicinity of Point Barrow and east to the oil lease areas located near Prudhoe Bay in the Beaufort Sea. The base of operations and aircraft support were provided by the Naval Arctic Research Laboratory at Point Barrow, Alaska.

The initial spring survey effort was in the Beaufort Sea oil lease area (fig B-1). This area proved to be extensively ice-covered and no whales were sighted. Subsequently, spring search flights were concentrated on primary leads that lay north and south of Point Barrow and east into the Beaufort Sea.

Survey flights were made during the fall migration period of September and October. The area surveyed included the Joint State-Federal Beaufort Sea oil lease area. Figure B-1 shows the general area of recordings in the spring and in the fall.

Once whales were located, sonobuoys were dropped. A sonobuoy is a passive listening device containing a hydrophone array and VHF transmitter. When dropped from an aircraft, its descent is slowed by a roto-chute or parachute. Once contact with the water is made, a saltwater-activated battery energizes the unit. At this time, the parachute assembly is jettisoned, and a hydrophone is dropped to a preselected depth. The sounds picked up by the hydrophones are amplified, telemetered to the aircraft receiver, and recorded. Two types of sonobuoys were used, the AN/SSQ-41A and the AN/SSQ-57A, with frequency responses of 10 Hz to 5 kHz and 10 Hz to 20 kHz, respectively. Hydrophone depth was 18 m.

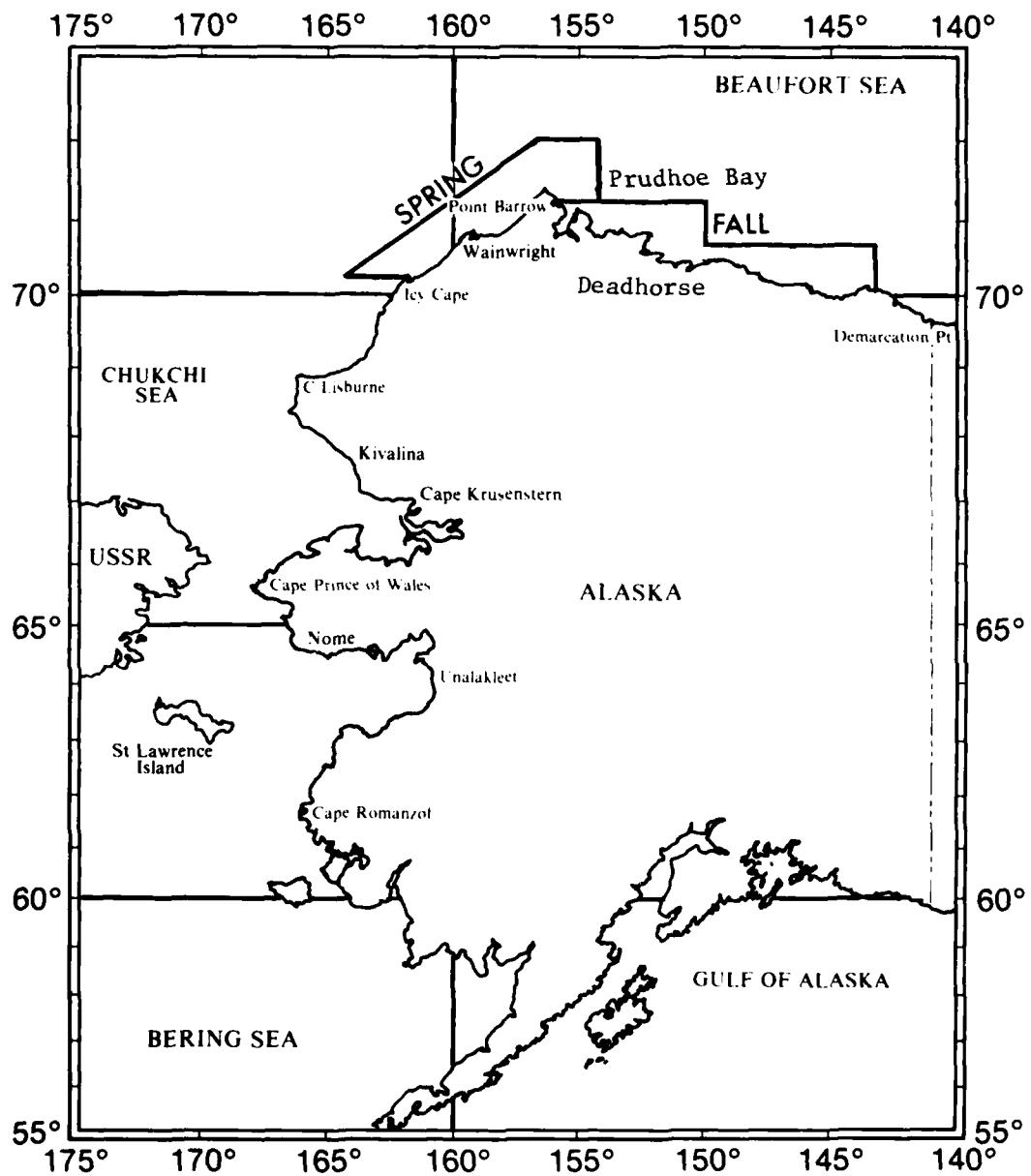


Figure B-1. Areas of bowhead acoustic recordings, spring and fall 1979.

Bowhead sounds were recorded with a broadband receiver (Defense Electronics GPR-20) coupled to a dual track Nagra IV SJ tape recorder. Signals were monitored via headphones while recording on one track, and notes about behavior and sound productions were made on the second track. When a sonobuoy was dropped, an attempt was made to place it in front of the whales as near as possible to their predicted course based upon the original sighting. The aircraft was maintained at about 60 m, the altitude required for an accurate and functional sonobuoy drop. The accuracy of the drop was important because although the leads were often many miles in length some were very narrow. When a successful drop was made, the aircraft returned to altitudes of 300 m or more to minimize the effects of aircraft noise, and the sonobuoy output was monitored and recorded while the area was circled for extended periods of time.

Bowhead sounds were analyzed using a real-time analyzer with a 3-dimensional spectrographic display system (Spectral Dynamics 301D). The response on this system was flat down to 50 Hz. A continuous hard copy spectrum of all sound sequences was produced. A sonograph (Kay-Elemetrics 7030A) was used to provide detailed frequency and duration analysis.

RESULTS

I. SPRING MIGRATION

Overview

Twenty-three flights were made searching for bowheads in open leads from 26 April to 20 May. Thirteen sightings were made during 11 of the flights. Sonobuoys were dropped in 12 of the sightings, 4 of which resulted in recordings of bowhead sounds. Of the nine sonobuoy drops not resulting in bowhead recordings, one (2 May) had inadequate signal-to-noise ratio for satisfactory analysis, and eight were limited to bearded seal (Erignathus barbatus) and beluga whale (Delphinapterus leucas) sounds.

Two tapes containing bowhead sounds were recorded on 6 May 1979 at N, 157°04'00" W southwest of Point Barrow in a large lead (up to 3.5 km wide) running north and south. At 0130 hours, two whales were sighted passing through the lead on a north course, followed about 45 min later by three more. Two sonobuoys were dropped, one in the northern part of the lead and the other 8.5 km farther south, in the path of the approaching whales. The aircraft circled the area and monitored both sonobuoys, recording from the sonobuoy with the best signal-to-noise ratio. This technique was advantageous because there were periods when the bowhead sounds were strong at one sonobuoy and weak at the other.

Two more tapes of whale sounds were recorded around noon on 10 May at $71^{\circ}38'00''$ N, $155^{\circ}00'00''$ W, approximately 75 km northeast of Point Barrow. The lead was approximately 1.95 km wide and oriented east to west. At 1138 hours two whales were sighted and a sonobuoy was dropped.

Bowhead sounds of good quality were recorded immediately and continued uninterrupted for 1.5 hours, during which 12 whales were sighted within 5.5 km of the sonobuoy, all moving northeast. On a return flight from Deadhorse to Point Barrow, another successful recording was made at $71^{\circ}46'00''$ N, $154^{\circ}10'00''$ W, about 33 km east-northeast from the location of the earlier recordings. Two bowheads were sighted next to the ice on the southern edge of a lead; upon approach of the aircraft, they immediately dove under the ice. A sonobuoy was dropped, and again, as in the midday recordings, sounds began immediately and were of good quality. The five tapes from these three encounters provided the analysis data for the spring study.

The bowhead sounds recorded on 6 May were the typical low frequency moans expected from most large mysticetes. Throughout the recordings gathered from the two 10 May flights there were, in addition to the typical moans, unique sequences of moans not previously recorded. These moan series are termed "sequential sounds", while all others are referred to as "nonsequential sounds".

Nonsequential Sounds

The nonsequential sounds were those that occurred with no discernible intersound pattern and consisted of: (a) simple moans, (b) complex moans, and (c) miscellaneous sounds. We defined "moan" as a sound whose duration was 400 msec or more and whose principal energy was below 800 Hz. A simple moan (fig B-2) was composed of sinusoidal or simple harmonic waveform. A complex moan (fig B-3) was any other low frequency sound and typically had a pulsive character. Complex moans had no appreciable harmonic structure. Miscellaneous sounds (fig B-4) were the few that could not be called moans and were not systematically analyzed. They included mainly short sounds such as chirps and grunts.

The analysis results for all simple and complex moans are presented in table B-1.

There were over three times as many simple moans as complex moans (numbers simple = 104, numbers complex = 33). The frequency of simple moan fundamental components ranged from an average low of 90 Hz to an average high of 158 Hz. Moan frequency was usually modulated. In 37% of the fundamentals the modulation was predominantly upward, in 25% predominantly downward, in 10% both upward and downward, and in 29% little or no modulation was observed.

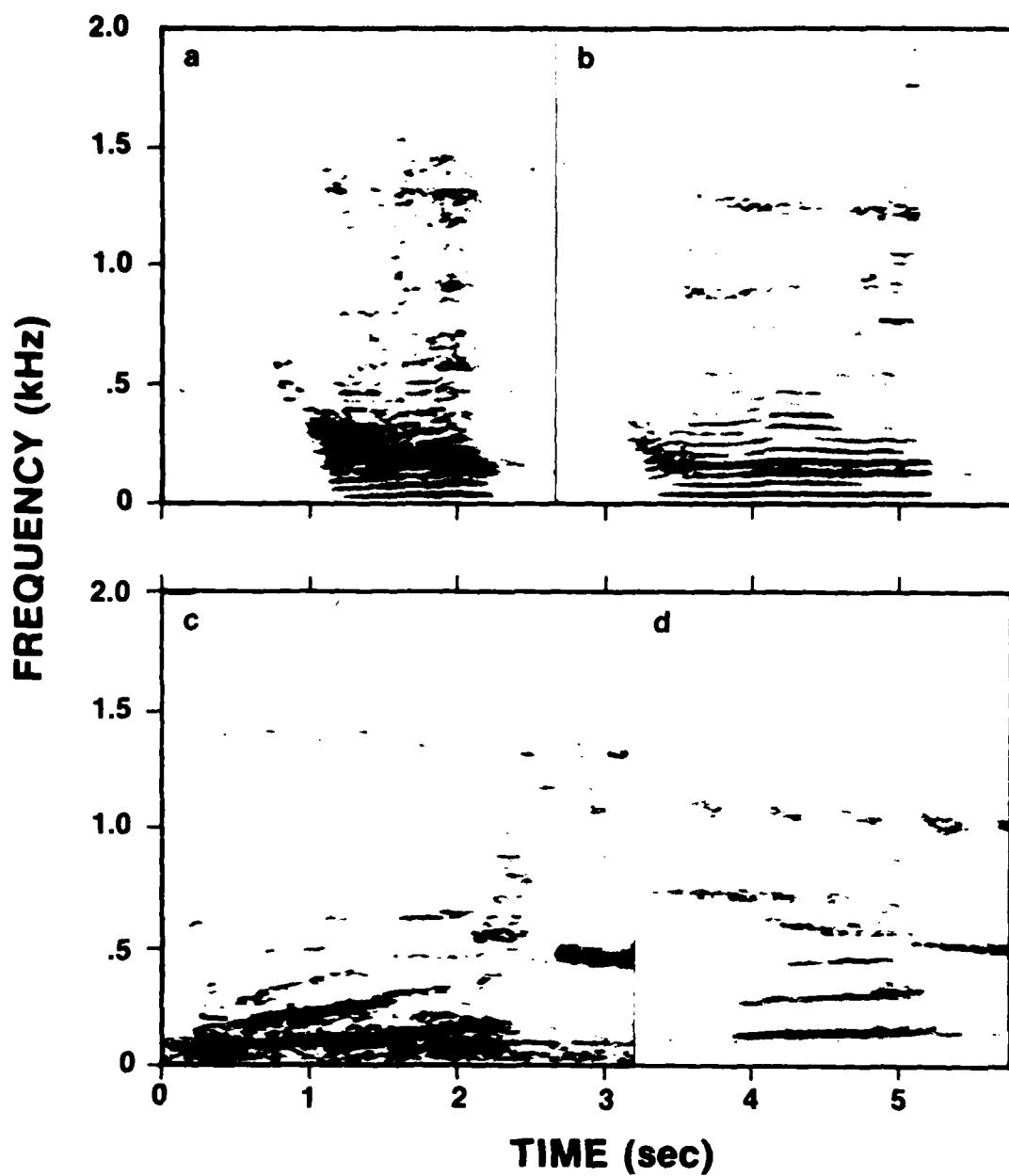


Figure B-2. Bowhead simple moan: tonal, frequency-modulated (FM) sound.

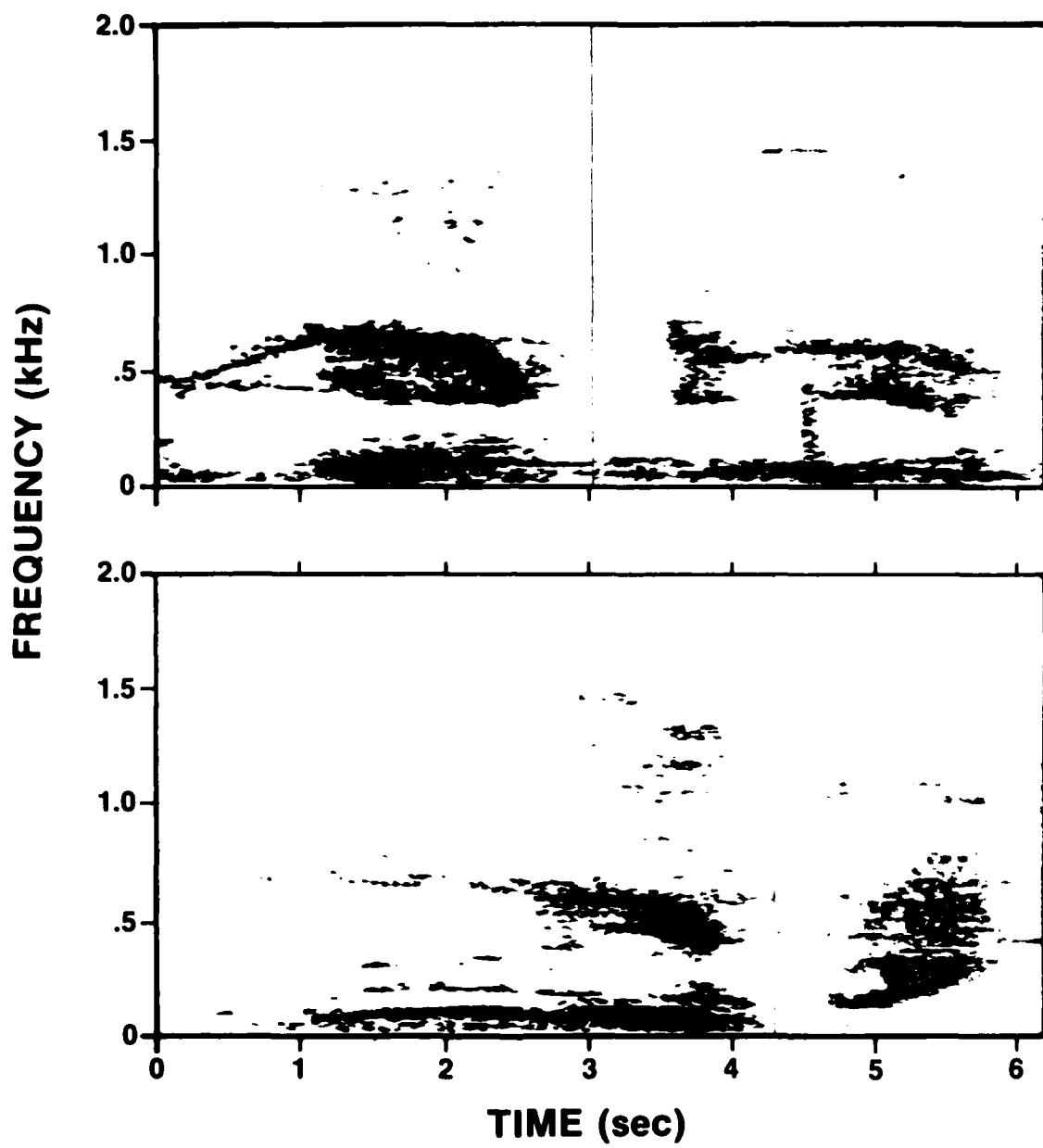


Figure B-3. Bowhead complex moan: pulsive, low frequency sound.

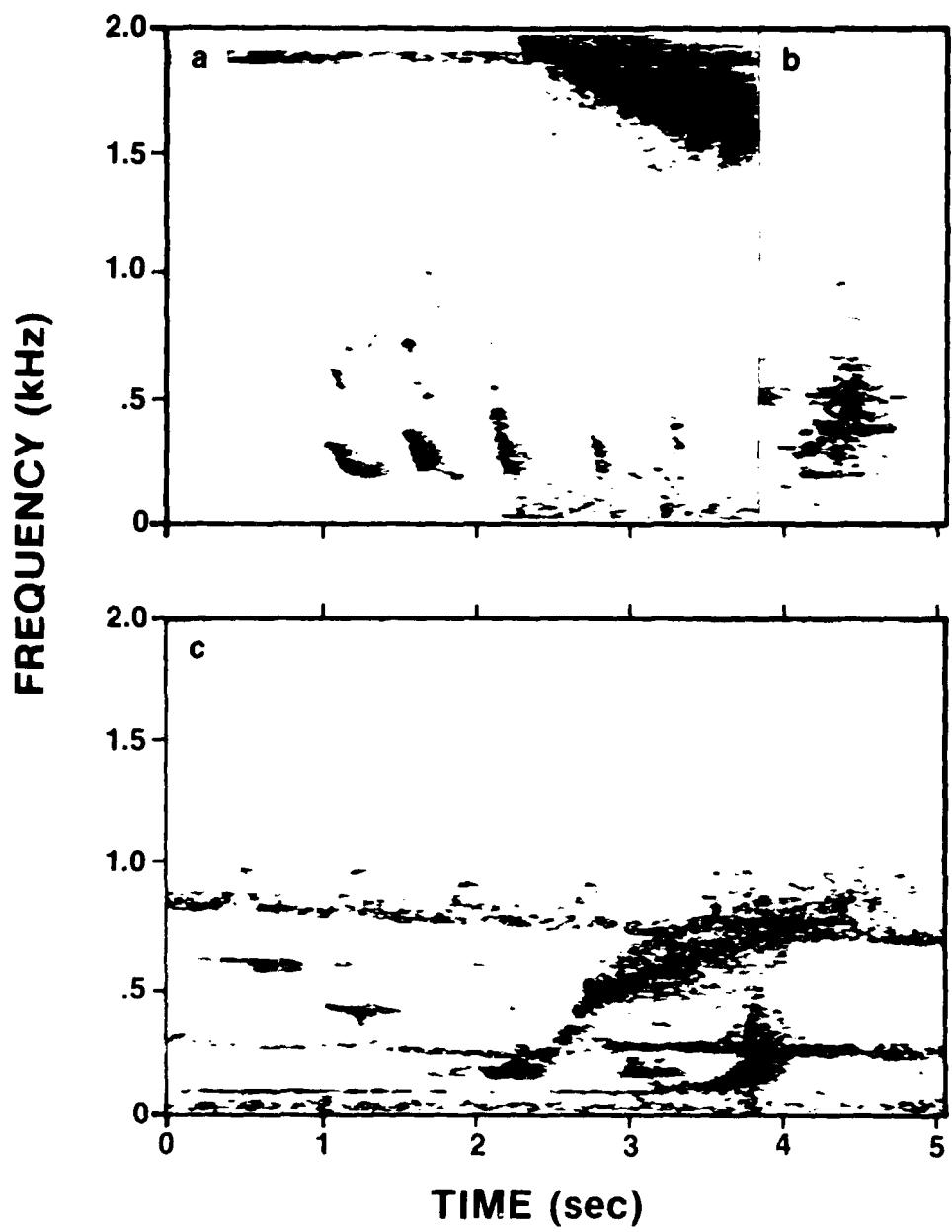


Figure B-4. Bowhead miscellaneous sounds: short chirps and grunts.

Table B-1. Spring sample: frequency and duration of nonsequential sounds.

	N	Range	Median
SIMPLE MOAN	104		
Lower limit (Hz)		25-425	80
Fundamental only (Hz)		25-360	90
Higher limit (Hz)		55-2000	500
Fundamental only (Hz)		30-600	158
Harmonics		0-13	3
Duration (sec)		0.4-3.3	1.3
COMPLEX MOAN	33		
Lower limit (Hz)		30-370	70
Higher limit (Hz)		55-2000	900
Duration (sec)		0.4-3.8	1.3

The number of harmonic components ranged from 0 ($N = 37$) to 13 ($N = 1$), with a median of 3. The total frequency range (including harmonics) of simple moans was from 25 Hz to 2000 Hz, with a median low of 80 Hz and median high of 500 Hz. The median of the average frequencies of simple moan fundamentals was 115 Hz.

Complex moan frequencies ranged from a median low of 70 Hz to a median high of 900 Hz. The frequency modulation of complex moans was found to be 45% upward, 27% downward, 12% mixed, and 15% little or no frequency change. The total frequency range of complex moans was from 30 Hz to 2000 Hz.

Median duration for both moan categories was 1.3 sec; minimum duration was 0.4 sec (the minimum limit by definition of the term "moan"). The longest simple moan was 3.3 sec and the longest complex moan was 3.8 sec.

Repetition Interval of Nonsequential Sounds

In the first part of the 6 May recording there were 20 simple moans recorded from the north sonobuoy. Using details of fundamental frequency, appearance of sonograph image, sound intensity changes with time and animal size, we inferred that there were two source bulls, one near the sonobuoy and one distant; and that one produced 12 moans in 44 min, and the other produced 8 in 22 min. The repetition interval for the first whale was 3.7 min, that for the second was 2.8 min. There were only four other simple moans in that part of the recording (over a 20-min period), and these could have been emitted by a whale accompanying the closer bull. This section was followed after 42 min by a shift to recording from the south sonobuoy as three to five whales approached it. In the following 26 min of recording from that sonobuoy there were 74 bowhead moans, both simple and complex, with such variety as to suggest that at least 3 whales were producing them. In one concentration of sounds, there were 31 moans in 4 min, or an average repetition interval of less than 8 sec. Earlier in the same period, there had been similar clusters of 13 and 20 moans. After these flurries there were only four moans in the last 30 min of recording.

In the 10 May midday recording, during which 12 whales were sighted, there were 19 nonsequential moans in the first 44 min (repetition interval ≈ 2.3 min), and only 2 in the last 43 min. In the 10 May evening recording with 2 whales sighted, there was a cluster of 14 moans in the initial 6-min segment, and 10 moans in the remaining 34 min of recording.*

*It was impossible to determine the number of whales producing sounds in either segment.

Sequential Sounds

Unique sound sequences were noted throughout the three recordings gathered on 10 May.

Twenty-two complete sequences from the first tape of 10 May (1138 to 1216 hours) were analyzed; the frequency and duration results are presented in Table B-2. Five sequences were not included because they were masked by other sounds. The sequences were composed of: a) ripple moans, b) glide moans, and c) adjunct moans. Ripple moans were amplitude-modulated sounds composed of 5 to 10 resonant pulses with an approximate 30 per second repetition rate. These moans were usually preceded by, and transformed from, glide moans, so named because they modulated toward the principal frequency of the ripple moans (Fig. B-5). Glide moans were basically tonal, or sinusoidal, in nature. Some ripple moans were accompanied by lower frequency tonal moans called adjunct moans, which were often frequency-modulated in inverted "V" form and were typically of shorter duration than the ripple moans which they accompanied (fig B-6). Frequently, part of the glide moans were missing or very weak (fig B-5a and b); sometimes a ripple moan was not preceded by a glide moan (third ripple moan in each of fig B-6a and b).

In 20 of the 22 sequences analyzed, at least one ripple moan in each sequence was accompanied by an adjunct moan in the 100 to 250 Hz region. The main frequency concentration of ripple moans changed within a series, for sequences with at least 7 moans. The frequency concentration typically began around 550 Hz, increased to about 650 Hz by the third moan, and decreased to below 450 Hz during the last four moans. Figure B-7 shows patterned frequency shift results from 16 sequences of 7 to 10 moans each. Sequences of five to six moans each were not included because they did not consistently show the pattern of frequency change.

Other Mammal Sounds Recorded

Bearded seal vocalizations of moderate to high signal-to-noise ratio were present most of the time on all of the five tapes analyzed for bowhead sounds. They were in the form of songs, which consisted mainly of (a) trills gradually descending in frequency (in the 3.0 to 0.3 kHz range) with quick up-sweeps in between, and (b) terminal moans of 203 sec in the 200 to 500 Hz region with a downward frequency shift as reported by Ray, et al. (1969). Usually only one song was heard, but it was not uncommon to hear two at once.

Belugas were more conspicuous, since they were in groups and were at or near the surface most of the time. At times they seemed to travel in close association with the bowheads. In addition to click trains, their sound output consisted mainly of whistles, squeals, and screams. The beluga sounds were most apparent at frequencies above

Table B-2. Spring sample: frequency and duration of sequential sounds.

	N	Range	Median	Mean	Standard Deviation
GLIDE MOAN	155				
Start (Hz)		200-500	350	355	39
End (Hz)		300-750	500	495	66
Duration (sec)		0.5-4.2	1.7	1.8	0.7
RIPPLE MOAN	171				
Main concentration (Hz)		380-800	570	562	93
Upper limit (Hz)		600-2000	1500	1507	307
Lower limit (Hz)		250-600	400	423	82
Duration (sec)		1.1-5.4	2.7	2.7	0.8
ADJUNCT MOAN	39				
Average (Hz)		100-300	173	184	30
Intersound interval (sec)	148	0.3-8.6	1.5	2.2	1.6
Complete sequence (sec)	22	25-74	52	49.0	13.3
Intersequence interval (sec)	19	1.7-22	13	12.8	6.0

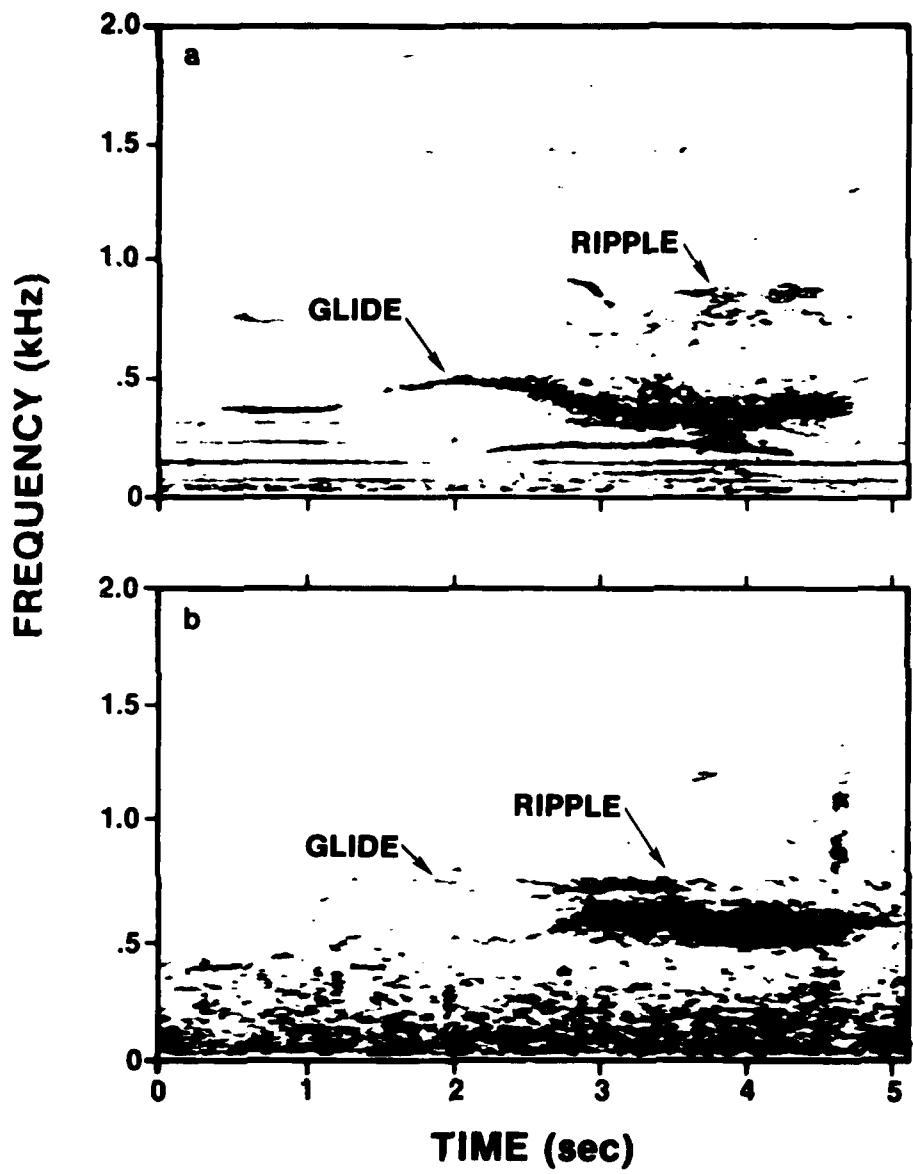


Figure B-5. Bowhead sequential sounds: 5a, ripple moan with glide moan; 5b, ripple moan with weak glide moan.

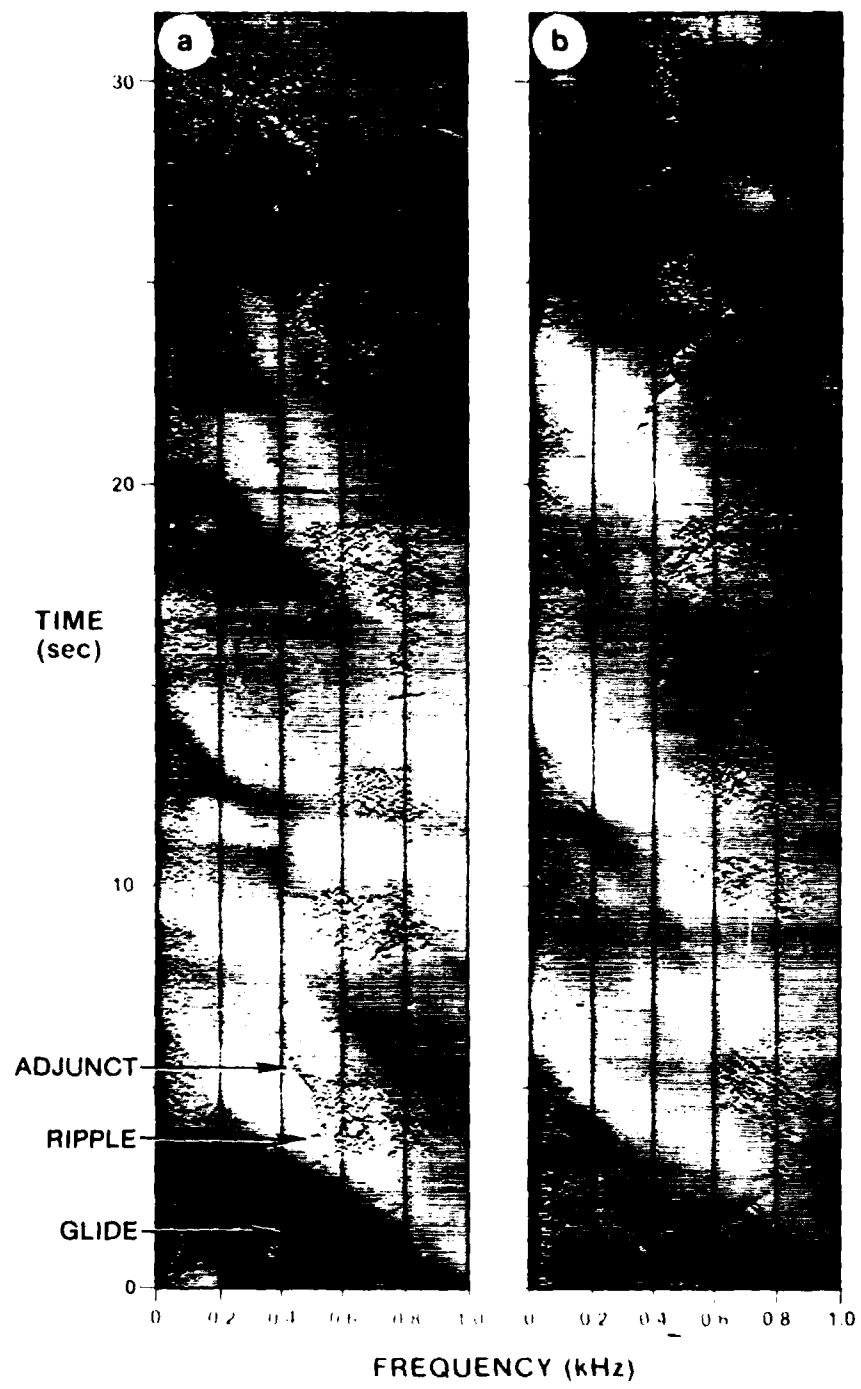


Figure B-6. Bowhead sequential sounds: two moan series showing glide, ripple, and adjunct moan components.

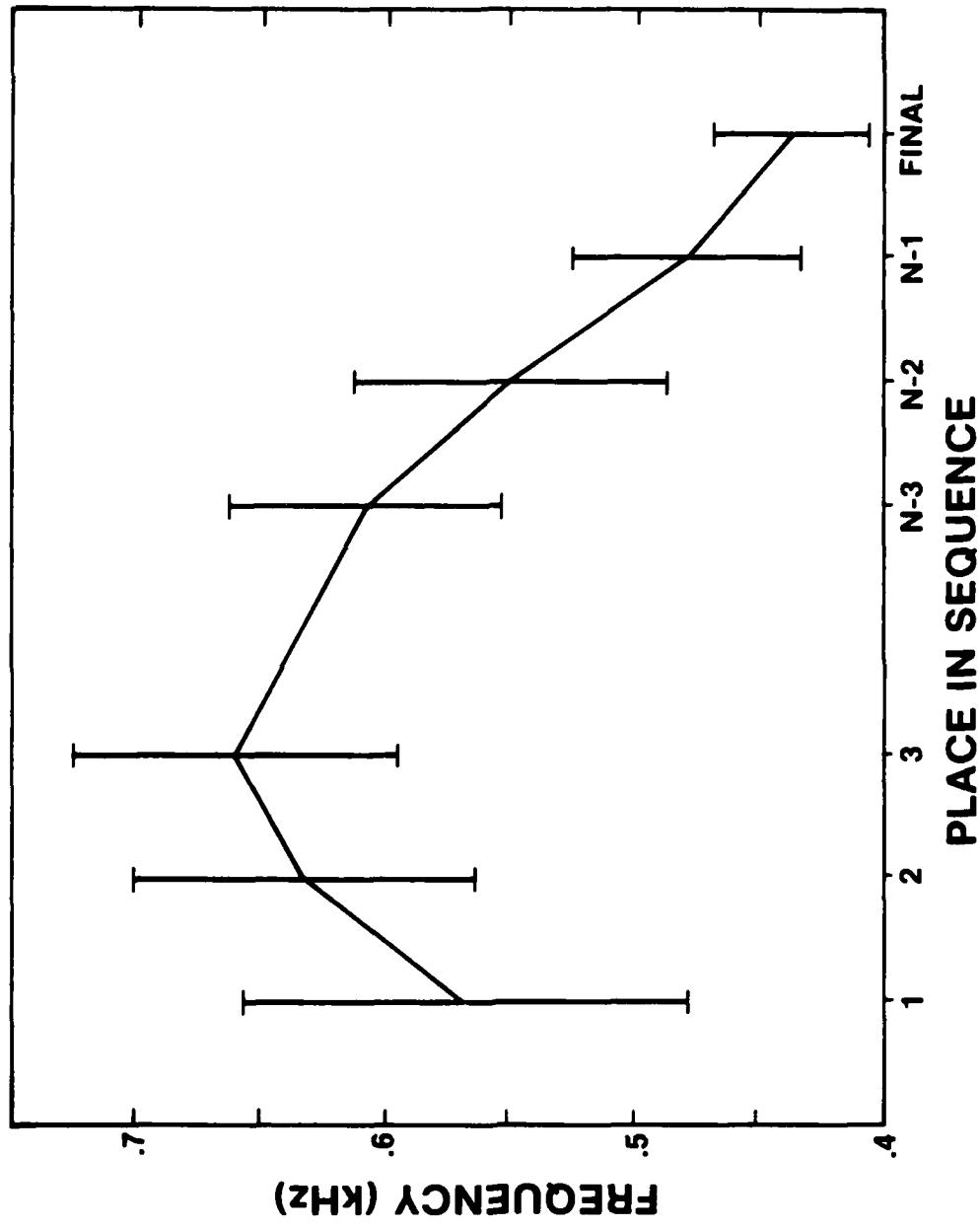


Figure B-7. Patterned frequency shift of bowhead ripple moans, for sequences of 7 moans or more. Values averaged from 16 sequences of 7 to 10 moans each.

500 Hz. Choruses of beluga sounds occurred on all five tapes analyzed, sometimes with good signal levels.

II. FALL MIGRATION

Overview

Fourteen survey flights were made from 8 to 19 October. Nineteen sonobuoys were successfully deployed on seven of the flights. Bowheads were recorded for 437 min over 16.4 hours of observation. Table B-3 summarizes data collection for each date. Sound production ranged from 2.8 to 23.8 sounds per min with an average of 10. The minimum number of whales observed within 2 to 4 km of the recording sonobuoy ranged from 0 to 13, with a mean of 3.7. Generally, more whales resulted in greater sound density. Although the general migration was westward, many whales were observed headed in other directions, motionless at the surface, or milling around. Two cow-calf pairs, three large (12 to 14 m) and several smaller whales are described.

Most bowhead sounds recorded in the fall were moans. In addition to simple and complex moans there were short grunts, thumps, and knocks falling into the miscellaneous sound category as well as short intervals of raucous sounds that at times included bellow, screech, and whistle components. These raucous sounds ranged to 4 kHz and occasionally had concurrent moan components. No sequential sounds were recorded from the bowheads in the fall.

An analysis of all moans recorded in the fall sample was deemed prohibitive. Portions of two tapes (sonobuoy 9, flight 6; sonobuoy 15, flight 8) containing 887 moans (total time = 90 min) were selected for analysis because they were recorded in the presence of several whales, including a cow-calf pair. The objective in making these selections was to obtain samples representative of a variety of bowhead whales.

Nonsequential Sounds

The simple and complex moan categories were further divided into two subcategories, types a and b. Simple moans were classed as a simple harmonic waveform with (a) little or no pulsive characteristics (without amplitude modulation) (fig B-8a), or (b) considerable pulsiveness (with amplitude modulation) (fig B-8b). Complex moans were those moans that were basically pulsive with (a) continuous, rapid amplitude modulation resulting in harmonic (tonal) components (fig B-9a), or (b) slower, non-uniform amplitude modulation resulting in nontonal components (fig B-9b). The frequency characteristics of the 887 moans analyzed are presented in table B-4.

Table B-3. Fall sample: number of bowhead whale sounds recorded listed serially by sonobuoy.

Sonobuoy Number	Flight Number	Sonobuoy Location (Lat, Long)	Count	Recording Time (Min)	Sounds Per Min	Minimum Whales Seen
1	1	70°38', 147°10'	195	21	9.3	1
2	1	70°40', 147°11'	28	10	2.8	5
3	3	70°35', 148°(approx)	28	5	5.6	2
4	3	70°35', 148°(approx)	139	25	5.6	13
5	5	70°37', 147°50'	92	15	6.1	2
6	5	70°31', 147°16'	79	10	7.9	1
7	6	70°37', 147°43'	387	57	6.8	5
8	6	70°36', 147°40'	23	3.7	6.2	2
9	6	70°31', 147°13'	557	75	7.7	3
10	7	70°34', 147°43'	25	4.7	5.3	0
11	7	70°38', 146°52'	349	31	11.3	1
12	7	70°31', 146°15'	184	20	9.2	2
13	7	70°42', 147°58'	144	17	8.5	2
14	7	70°43', 147°02'	51	10	5.1	5
15	8	70°24', 146°03'	1567	89	17.6	6
16	8	70°25', 146°(approx)	31	1.3	23.8	6
17	14	71°11', 151°39'	103	11	9.4	4
18	14	71°11', 151°40'	57	6	9.5	4
19	14	71°08', 151°09'	299	25	12.0	6
TOTAL			4358	437	10.0	70

MEAN = 3.7

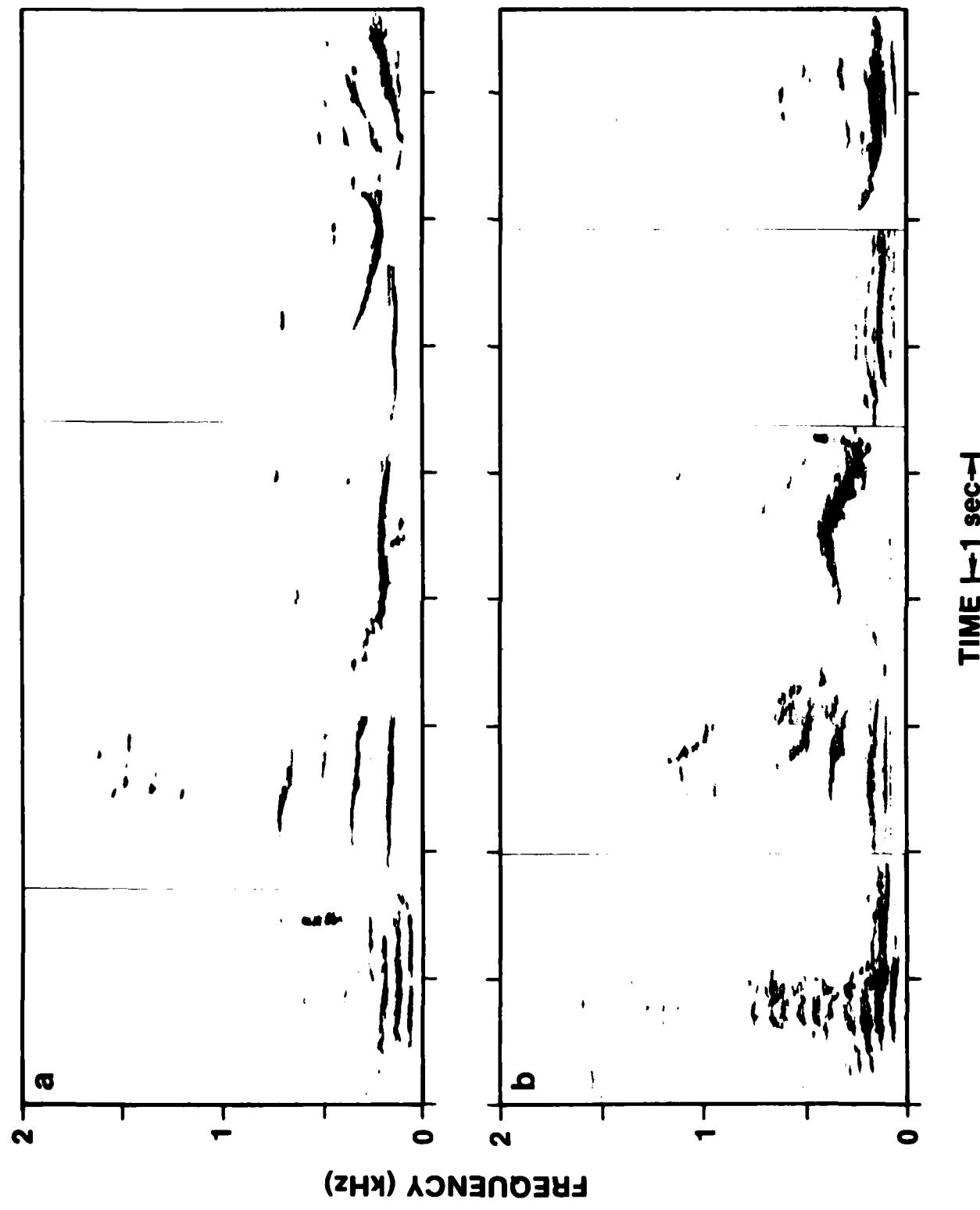


Figure B-8. Bowhead simple moan subcategories. Tonal sounds with 8a, little or no pulsive character; considerable pulsiveness.

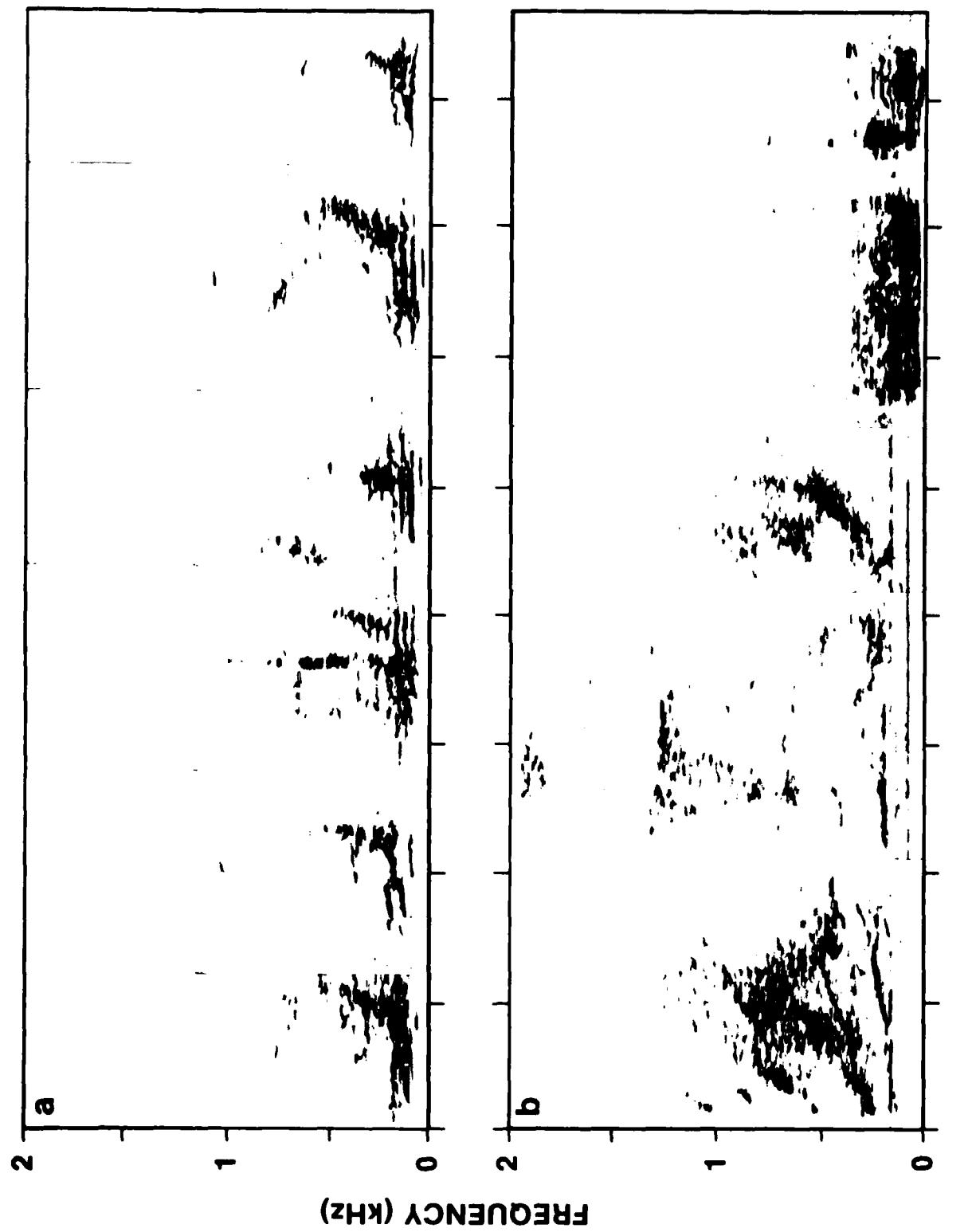


Figure B-9. Bowhead complex moan subcategories, pulsive sounds with:
9a, rapid amplitude modulation resulting in harmonic components; 9b, slow,
nonuniform amplitude modulation.

Table B-4. Fall sample: frequency and duration of nonsequential sounds.

	N	Range	Median
SIMPLE MOAN			
a. Without amplitude modulation	619		
Lower limit (Hz)		20-475	100
Fundamental only (Hz)		25-475	110
Higher limit (Hz)		80-2000+	400
Fundamental only (Hz)		40-650	165
Harmonics		1-16	3
Duration (sec)		0.4-3.2	1.1
b. With amplitude modulation	159		
Lower limit (Hz)		20-370	80
Fundamental only (Hz)		20-370	110
Higher limit (Hz)		130-2000+	60
Fundamental only (Hz)		50-540	170
Harmonics		1-14	2
Duration (sec)		0.4-3.2	1.0
COMPLEX MOAN			
a. Mainly tonal AM components	76		
Lower limit (Hz)		30-130	52
Higher limit (Hz)		200-2000	435
Harmonics		2-9	4
Duration (sec)		0.4-3.2	1.0
b. Mainly nontonal AM components	33		
Lower limit (Hz)		20-200	60
Higher limit (Hz)		170-2000+	500
Duration (sec)		0.4-3.2	1.1

As in the spring, the simple moans outnumbered the complex moans (numbers simple = 778, numbers complex = 109). Of the simple moans, 619 (80%) were type a with little or no amplitude modulation, and 159 were type b with amplitude modulation. The simple moan fundamental ranged from an average low of 110 Hz to an average high of 165 to 170 Hz, with an overall median frequency of 140 Hz. In 36% of all simple moans, the frequency shift within the sound was upward, in 18% the frequency shift was downward, 20% had essentially no frequency shift, and 26% showed complex combinations of up, down, and sustained frequency elements. The number of harmonic components ranged from 0 (fundamental only) to 16; the median number of harmonics for simple moans without amplitude modulation was 3, for those with pulses, 2. The total frequency range (including harmonics) of simple moans was from 20 to 2000 Hz.

There were 76 tonal and 33 nontonal complex moans. The median frequency limits for both types ranged from a low of 52 to 60 Hz, to a high of 435 to 500 Hz. The frequency modulation was 40% upward, 7% downward, 20% no shift, and 33% mixed. The median number of harmonics for tonal complex moans was four. The total frequency range (including harmonics) was 20 to 2000 Hz. Tonal complex moans had a median pulse rate of 50 per sec, with a range of 25 to 140 pulses per sec. The median pulse rate for all other moans having pulsive characteristics was 20 per sec, with a range of 10 to 100 pulses per sec.

Moan duration for all types ranged from 0.4 to 3.2 sec. The median durations for simple moan types a and b were 1.1 and 1.0 sec, respectively; for complex moan types a and b, 1.0 and 1.1 sec, respectively.

Repetition Interval of Nonsequential Sounds

Sonograms of the analyzed moans were closely reviewed for intermoan similarities, taken as evidence of a common source. We found 21 moan sets of 2 to 10 moans, in which all moans could have been emitted by the same whale. The average set contained four moans. The median of the 66 repetition intervals contained in the 21 sets was 71 sec.

Three moan sets are shown in figures B-10a, B-10b, and B-11. The 10-min break between the third and fourth moans in Figure B-10a, and the noticeable change in pattern at this point suggest that the fourth and fifth moans may have come from a different whale. Discounting the 10-min break, the repetition interval for the simple moan series in figure B-10a averaged 1 min 45 sec; the interval in figure B-10b, simple moan series averaged 1 min 13 sec. The average repetition interval of the complex moan series in figure B-11 was 18 sec; very short when compared with those series of figure B-10. This illustrates one extreme of interval distribution.

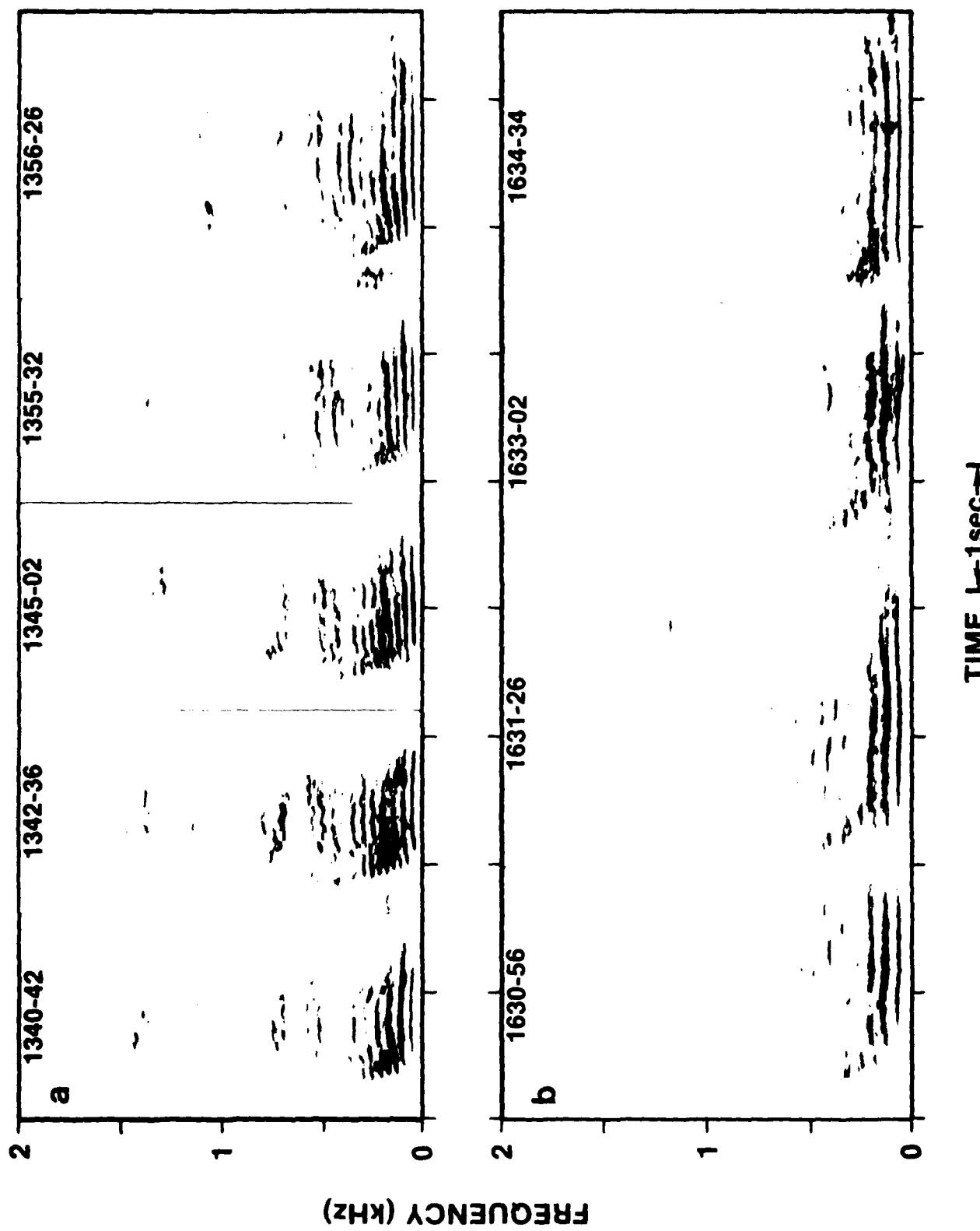


Figure B-10. Two bowhead simple moan series: 10a, repetition interval = 1.75 sec; 10b, repetition interval = 1.25 sec.

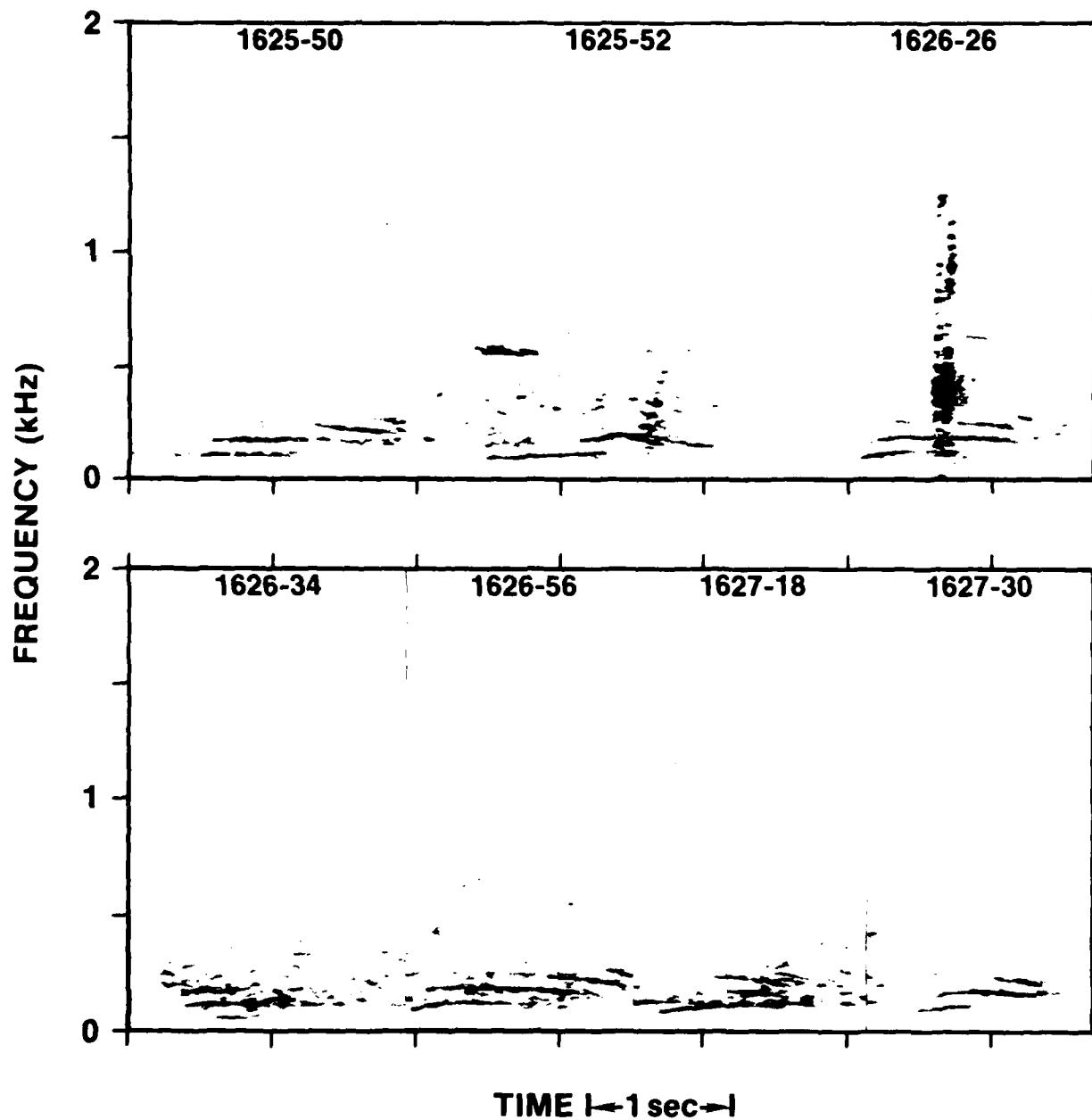


Figure B-11. Bowhead complex moan series: average repetition interval = 18 sec.

High Frequency Sounds

In addition to moans and miscellaneous sounds with average frequencies below 800 Hz, raucous high frequency (to 4000 Hz) calls were recorded from the bowheads in the fall (fig B-12). These calls were variable, some sounding like the trumpeting of elephants, some like the meowing of cats, and many that could best be described as screeching. These high frequency sounds were widely scattered throughout 7 of the 11 fall tapes (5 of 7 flights).

Thirty-one of the best high frequency calls were analyzed. The low, high, and fundamental frequency ranges were 40 to 1250 Hz (median 200 Hz), 2500 to 4000 Hz (median 3700 Hz), and 800 to 2500 Hz (median 1600 Hz), respectively. Most of these sounds were characterized by prominent amplitude modulation in the range of 30 to 120 pulses per sec (median 50 per sec); all contained at least some amplitude modulation. Duration ranged from 0.4 to 4.0 sec; the median duration was 1.6 sec.

Other Mammal Sounds Recorded

In contrast to spring conditions, the fall recordings were almost free of interfering bearded seal and beluga whale sounds. The only other marine mammals in the recording area were ringed seals. Weak beluga and ringed seal sounds were occasionally present in the background. Another prominent biologic sound was made up of slow trains of "knocks" from an unidentified source which were recorded on three flights (fig B-9a, simultaneous with third moan; fig B-11, simultaneous with moan 1626-26; fig B-12, simultaneous with third moan). These sounds did not mask nor interfere with bowhead sound analysis.

DISCUSSION

Overview

The bowhead sounds presented here were collected over a 4-week spring and 12-day fall period in 1979, coinciding with migratory phases for this species. All sounds were collected in the vicinity of Point Barrow and east while conducting aerial surveys of the bowhead migration in and around the Beaufort Sea oil lease areas. A larger sound sample was collected during the fall survey flights, though over a shorter time period. Many spring recordings contained no bowhead sounds.

Nonsequential Sounds

Bowhead moans were present in both spring and fall samples. In each sample these low frequency sounds were divided into simple moans,

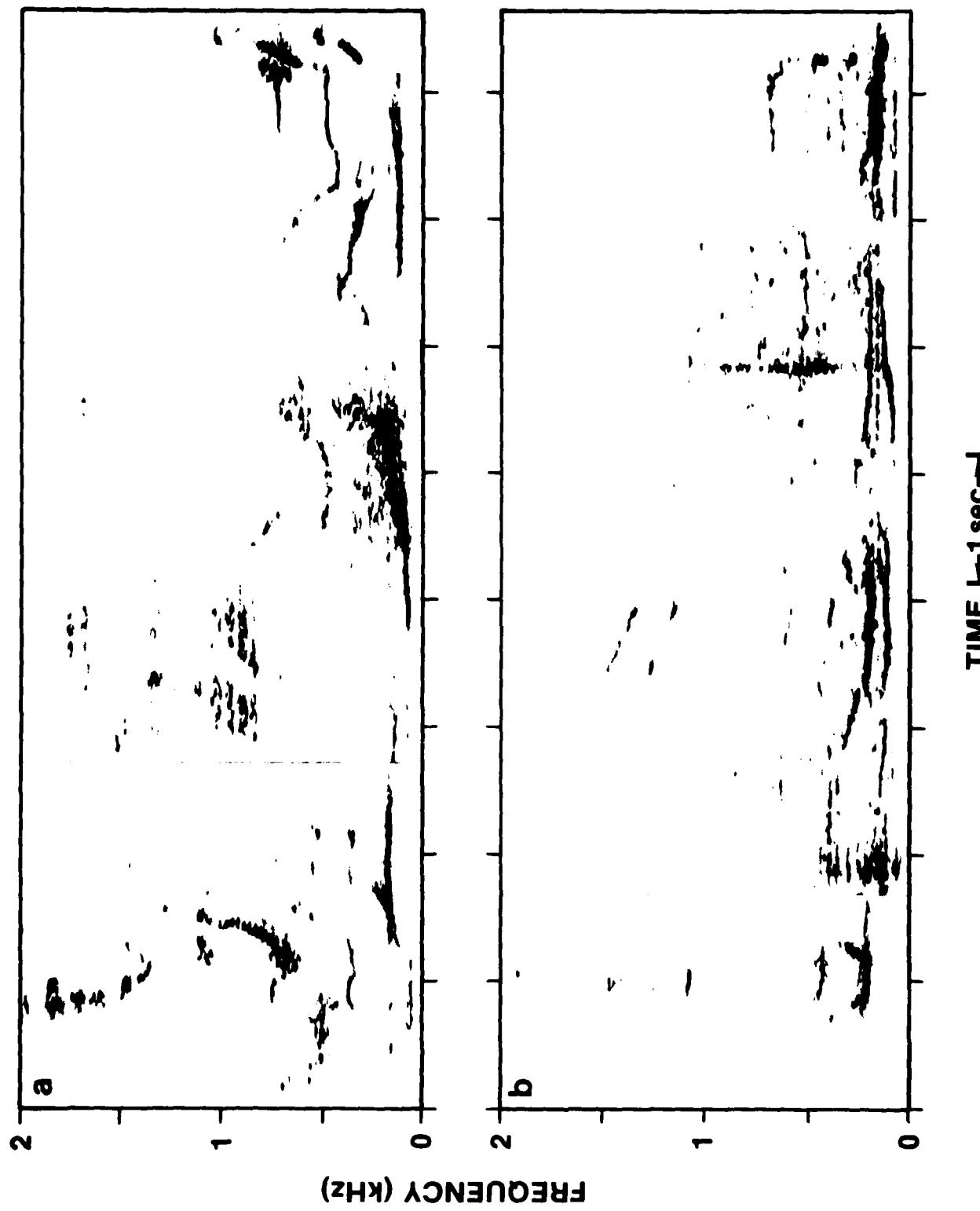


Figure B-12. Bowhead high frequency sound: elephant trumpet or screech.

those having a general tonal quality, and complex moans, those having a pulsive nature. Some moans recorded in the fall were difficult to interpret and categorize. Moans with simultaneous tonal components having no consistent harmonic relationship were particularly puzzling. Generally, these were treated as simultaneous moans from two whales, but the last three samples shown (Fig. B-11) could not be treated that way; they showed too much evidence of dual sound generation in the same animal. This type of moan plasticity necessitated the subcategories of simple and complex moans with and without pulsive and/or harmonic characteristics for the fall sample.

In the spring the proportion of simple moans to complex moans was 3:1, as compared with 7:1 in the fall. The frequency and duration characteristics of the moans were very similar in both seasons. Simple moan mean frequencies were somewhat higher than those of complex moans. The frequency range (including harmonics) in both moan categories was approximately 25 to 2000 Hz for both seasons. Frequency modulation in moans was similar in both seasons, with the most common shift being upward. The fall moan sample showed fewer downward frequency shifts and a higher proportion of moans with complex combinations of frequency inflection. Moan duration ranged from 0.4 sec (definition) to just over 3 sec in all samples with a median duration of slightly over 1 sec.

Estimation of Number of Whales From Repetition Interval of Nonsequential Sounds

It would be advantageous to any study of marine mammals to be able to estimate population size (and movement) from acoustical data. Nonsequential sounds that appeared to be produced by one individual were recorded in both the spring and fall. In the spring (6 May) recordings, two whales emitting low frequency simple moans showed repetition intervals averaging 3.7 and 2.8 min. In the fall data, there were a pair of similar series with average intervals of 1.75 and 1.25 min.

There are many problems inherent in attempting to estimate the number of whales from sound production. A few of the more obvious problems include:

- a. Silent whales: Sonobuoys have been dropped in bowhead groups of 20 or more with no sounds audible.
- b. Sound clustering: Bowhead sounds are often produced in flurries, followed by long silent intervals.
- c. Sound masking: The biologic din created by phonating bearded seals and beluga whales in the spring may effectively mask bowhead sounds needed for an accurate count of moans.

With these precautions in mind, we attempted a trial estimation using the fall data.

The two simple moan series presented in figure B-10 had below average (<140 Hz) fundamental frequencies. Thus far moan series have been ascribed to one individual when intermoan frequency measures are similar. In this way, we assume the 1.75 and 1.25 series intervals to be typical of all fall simple moans with a fundamental of <140 Hz (ie, $N = 778/2$ or 389 moans). If we establish 1.5 min as the average repetition interval, and assume the whales are stationary, then 6.5 whales could have accounted for the 389 lower-than-average frequency simple moans recorded in the 90-min sample. If we assume whales may move in and out of sonobuoy range over a 30-min period, the minimum number of whales emitting sounds over the 90-min sample would be 3×6.5 , or approximately 20. If the 389 higher-than-average frequency moans were made by other whales producing them with similar recurrence intervals, we might estimate a total of 40 whales emitting simple moans and passing within about 2 km of the sonobuoy. Complex moans (fig B-11) were produced at a much faster rate; repetition interval averaged 18 sec. Assuming complex moans were produced by other whales, we estimate 1 to 3 more whales responsible for the 109 complex moans in the fall sample. The total estimate is about 42 whales passing within sonobuoy range during the 90 min of recording.

The number of whales sighted was 9, but since whales generally are at the surface only a short time and the airborne whale observers were in good position to view the sonobuoy area only a modest fraction of the time, it seems possible that moans from about 42 whales were recorded. On the average, each whale would have emitted 21 moans while passing through the area within good reception range of the sonobuoy.

Judging by experience with other migrating whales (Cummings *et al*, 1968), this number of moans per whale seems high. Under better observing and recording conditions, the greatest number of moans emitted by a single whale while within hydrophone range was 15, as compared with the 21 we hypothesize in the present case. It would seem that the number of bowheads producing sounds represented by the recorded moans might be more than 42.

An important point, previously mentioned, is the proportion of whales in an area which were relatively silent over long periods of time. In the case of migrating gray whales, the great majority were silent as they passed within range of the hydrophones (Cummings *et al*, 1968). In the cases of humpback whales in Hawaii and Alaska (Thompson *et al*, 1978) and right whales in Argentina (Cummings *et al*, 1972), the majority of whales in an area during a recording session seemed not to be producing sounds, although both species are noted for their loquaciousness.

In summary, the number of sounds recorded per unit time in some of the fall bowhead recordings suggests that only a small proportion of the whales in an area were sighted.

Correlation of Sounds With Visual Observation

Recordings were made in the presence of two cow-calf pairs. In neither case were there any unusual sounds that could be attributed to the calf; the variety of sounds seemed no different from the usual. Similarly, the short intervals of raucous high frequency sounds found on most of the fall tapes had no observed relationship to behavior. Overt behavior may have been associated with these sounds, but was unobservable because most whale activity occurred below the surface and the whale(s) responsible for the sounds may not have been seen at all.

Sequential Sounds

Sequential moans were unique to the spring recordings. These sound sequences constituted a simple type of song; very short and unpretentious as compared with the song of the humpback whale (Megaptera novaeangliae). This simple song had just one theme with basically only two sounds repeated over and over, compared with the humpback's typical five or six themes, each composed of different elemental sounds in different patterns or phrases. In duration and complexity the bowhead song was similar to that of the bearded seal (Ray et al, 1969). The rising then falling nature of sequences of more than seven moans is similar to the tonal note description given by Aldrich (1889). In many ways it was most similar to sound sequences recorded by the NOSC Arctic Research Laboratory under ice-covered Bering Straits in 1970-1972 and described by Thompson (1978). Although the latter typically had two or three themes, there were enough similarities in frequency characteristics, sound element and duration, sound repetition interval, and inter-song interval that we suspect the Bering Strait sequences were also from bowheads.

Sequential Sound Comparisons, Conspecific and Interspecific

On an individual sound basis, the glide moan and adjunct moan were essentially the same as some of the sounds we classified as simple moans. Ripple moans had no counterpart in individually occurring moans in this study, but were very similar to certain moans in the 1957 Hawaiian humpback whale song (Thompson et al, 1977), which had a pulse repetition rate of 20 per sec and principal energy between 200 and 400 Hz. Like ripple moans, many complex moans had pulsed wave form but with widely varied pulse repetition rate and frequency content.

The pulsive nature of many humpback whale sounds was described by Payne and McVay (1971), Wynn *et al.* (1971), and Wynn *et al.* (1979). Wynn *et al.* (1979) quantified the pulsive nature of several categories of humpback moans, which varied in pulse repetition rate from 25 to 440 per sec.

Humpback whales also emit moans essentially similar to most bowhead moans we classified as simple and to some we classified as complex. The similarity to bowhead moans is even greater in the sounds of right whales, Eubalaena australis, which were studied extensively by Cummings *et al.* (1972, 1974), who described "belch-like" sounds (pulsating sounds that we would place in the complex moan category) and "simple" and "complex" moans, depending upon the number of harmonics (which we would place in the simple moans category). They also particularly described pulsive sounds made during underwater exhalations, which were essentially the same as some bowhead simple moans (1974). Payne and Payne (1971) divided right whale sounds into (1) tonal sounds and (2) atonal, pulsive, or rasping sounds, and pointed out that many sounds exhibited similar dual characteristics. We classified moans as simple or complex according to which characteristic seemed dominant.

Comparison of Spring 1979 With Spring 1978 Bowhead Sounds

The main differences between 1978 and 1979 recordings of spring bowhead sounds were (1) absence of any sequential sounds in 1978, and (2) lower moan fundamental frequency in 1979. In 1979, the fundamentals of many simple moans were near 30 Hz and the median of all was 90 Hz, as compared with a minimum frequency of 100 Hz and a median of 145 Hz for the 1978 counterpart, "type B" sounds. The median lowest frequency of a complex moan in 1979 was 70 Hz, as compared with 142 Hz for its 1978 counterpart. "Type A" sounds in spring 1978 were few in number and all may have been emitted by the cow of the cow-calf pair (the only bowheads sighted); the spring 1979 sounds were produced by as many as 25 whales (the estimated maximum number sighted in the general area of recording during the sessions).

In 1979 there were a total of 23 simple moans having fundamentals in the 30 to 70 Hz range and many harmonics, apparently produced by 4 or 5 whales. These we hypothesize were from mature bulls. There was a somewhat smaller number of complex moans with very low frequency components, which we also hypothesize were produced by mature bulls. Thus in 1979 the greater sampling likely included a wide variety of size and age in both sexes, resulting in more sonic variety, including components of much lower frequency.

High Frequency Sounds: Trumpeting

Braham *et al.* (1978) described trumpeting or elephant-like roars from bowheads during their fall migrations westward past Point Barrow.

These sounds, which had a pulse-train waveform (roughly 50 to 100 pulses per sec) and had substantial energy up to 3 kHz, were not heard in our spring recordings. Very similar sounds, which were described as "screeches", were a prominent part of December-January sound sequences recorded in the Bering Straits, presumably from bowheads and described by Thompson (1978).

These high frequency trumpeting or screeching sounds were scattered throughout our fall sound sample. Analysis of 31 of these calls found them to be high frequency, amplitude modulated calls generally lasting over a 1-1/2 sec. The function of this call remains unknown.

Other Mammal Sounds

Bearded seal and beluga whale sounds were conspicuous on all spring recordings. Bearded seal sounds were in the form of songs (Ray, 1969). The beluga whistles and squeals were most apparent at frequencies above 500 Hz.

In contrast, fall recordings contained few of such interfering sounds. Beluga sounds were heard occasionally, but never in chorus. Weak ringed seal sounds were occasionally recorded. The most conspicuous biological sounds on the fall recordings were slow "knock" trains recorded on three flights that occurred with, but did not mask, bowhead moans.

SUMMARY

Sounds were tape recorded from 15 to 25 bowhead whales near Point Barrow in 3 recording sessions during the 1979 spring migration. On two of these occasions, one or two whales emitted frequently recurring sequences of pulsive moans in the 500-Hz region. Succeeding moans in sequence increased in frequency at the sequence start and decreased toward the end; the number of pulsive moans in a sequence varied from 5 to 10. Sequences varied in duration from 25 to 74 sec and were separated by intervals that averaged 13 sec.

Other sounds recorded in spring were moans, simple (tonal) and complex (atonal and/or pulsed), which occurred at intervals ranging from a few seconds to a few minutes. The fundamental frequency of nonsequential sounds averaged considerably lower (90 Hz for simple moans) than in spring 1978, when sounds from a cow-calf pair were recorded, because some whales in the 1979 encounters, probably bulls, emitted sounds of lower fundamental frequency. In two concurrent series of simple moans, the apparent repetition interval was 4 min and 3 min. In general, there was great similarity between the moans of bowheads and those of humpback and right whales.

Bowhead sounds were sampled over a 12-day period during the fall migration. Simple and complex moans were divided into two types (with and without amplitude modulation) to reflect the diversity of the analyzed moans better. No sequential sounds were recorded in the fall. Unique to fall recordings were high frequency trumpeting or screeching sounds. These sounds appeared to be similar to those described by Braham *et al* (1978). The biological din from beluga whale and bearded seal sounds present in spring recordings was conspicuously absent from the fall data.

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APPENDIX C AERIAL SURVEY FLIGHTS

This appendix consists of flight tracks 1 through 106, which cover areas in the northern Bering Sea, the Chukchi Sea, and the Beaufort Sea during the period of mid-April to early November 1980. Flight tracks and sighting information are not included for flights made in the eastern Canadian Beaufort Sea in support of the bowhead tagging project. Table C-1 summarizes information relevant to the surveys, such as the number of hours flown and the number of flights in the study area.

Each flight is represented by a flight track/sighting chart, a descriptive caption, and a sighting table. Each symbol (●) on the flight track/sighting charts represents one or more whales. The sighting charts and tables include the positions and number of sightings only for bowhead and gray whales. Individual flight tracks and positions of sightings for other species are available upon request. For reference, each flight track caption notes any other species which were sighted. In addition, the total numbers of marine mammal sightings are listed according to species in table C-2. In areas with extremely large concentrations of beluga whales and walruses, only partial counts were made.

The flight track captions also describe the general ice conditions observed, and note whether the surveys included portions of the study area. The study area included the Beaufort Sea Federal Sale 71 and the Joint State-Federal oil lease areas, and may be referred to as the lease areas in some captions.

Clinometer angles are included in the fall sighting tables, and were used to derive an index of abundance for the study area. Aircraft speed averaged 222 to 259 km/hr (120 to 140 kn) and altitude varied, depending on the weather, from 30 to 549 m with an average range of 122 to 183 m.

Table C-1. Aircraft/Survey Effort

	Spring	Summer	Fall	Total
Number of hours flown	116.5	135.5	234.5	585.5
Number of days flown	36	31	49	116
Days down due to weather	8	6	10	24
Days down due to repairs	4	6	8	18
Surveys of Joint State-Federal area	12	8	17	37
Survey of Federal Sale 71 lease area	3	6	14	23
Transit flights	5	8	5	18
Flights aborted	3	5	5	13
Flights dedicated to other efforts	26	8	18	52

Table C-2. Marine Mammal Sightings.

	Spring*	Summer*	Fall*	Total*
Bowhead Whale <u>Balaena mysticetus</u>	314/857	229/685	36/49	579/1591
Beluga Whale <u>Delphinapterus leucas</u>	284/3404**	44/599	4/5	332/3755
Gray Whale <u>Eschrichtius robustus</u>	2/6	13/50	110/271	123/327
Ring Seal <u>Phoca hispida</u>	250/765	40/206	10/27	300/998
Bearded Seal <u>Erignathus barbatus</u>	45/71	5/7	10/21	60/109
Polar Bear <u>Ursus maritimus</u>	5/9	6/8	21/39	33/56
Walrus <u>Odobenus rosmarus</u>	45/695	5/5**	0/0	50/700

*Total number of sightings/total number of individuals. All counts include possible resightings.

**Partial counts.

No bowhead sightings for flight 1, 20 April 1980

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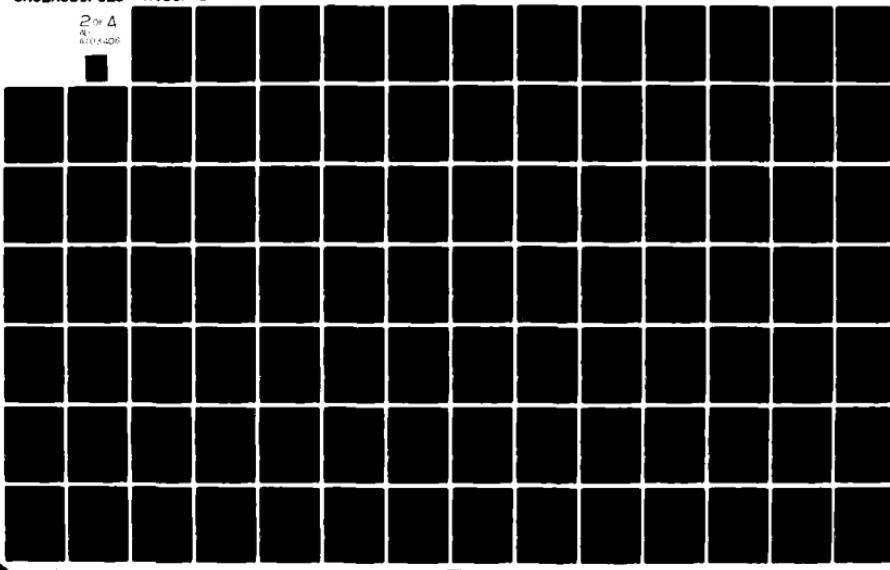
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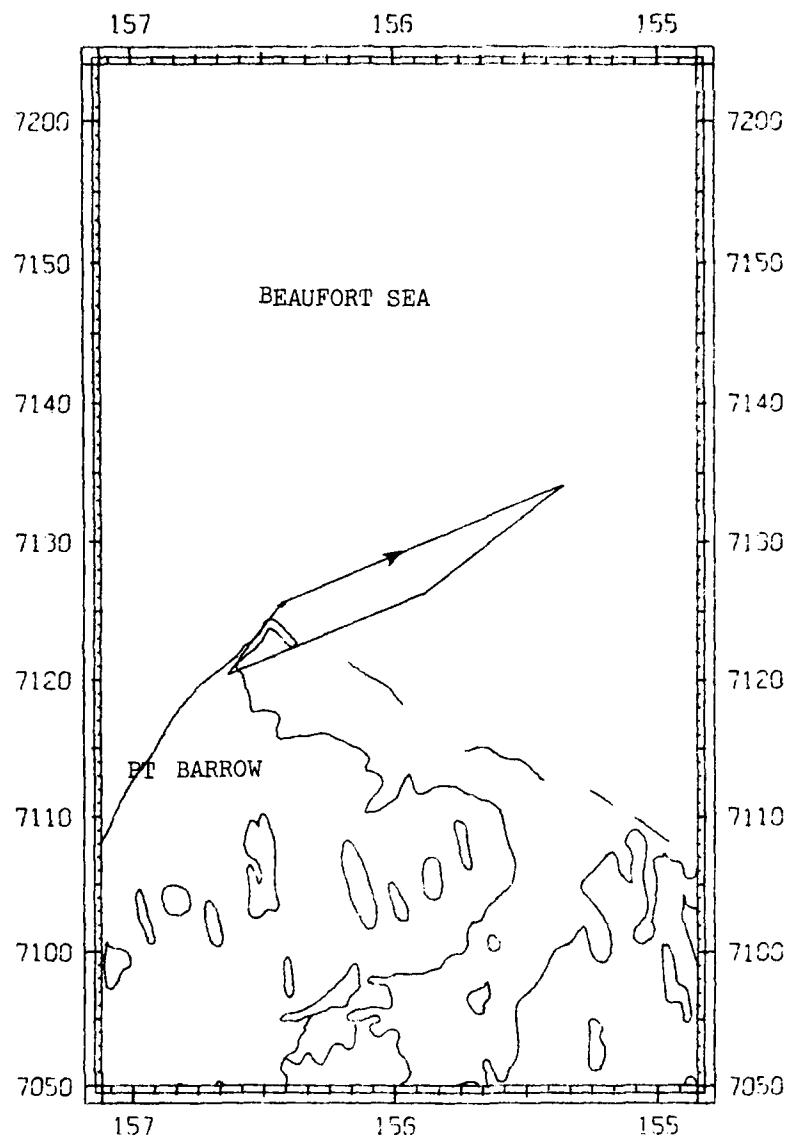
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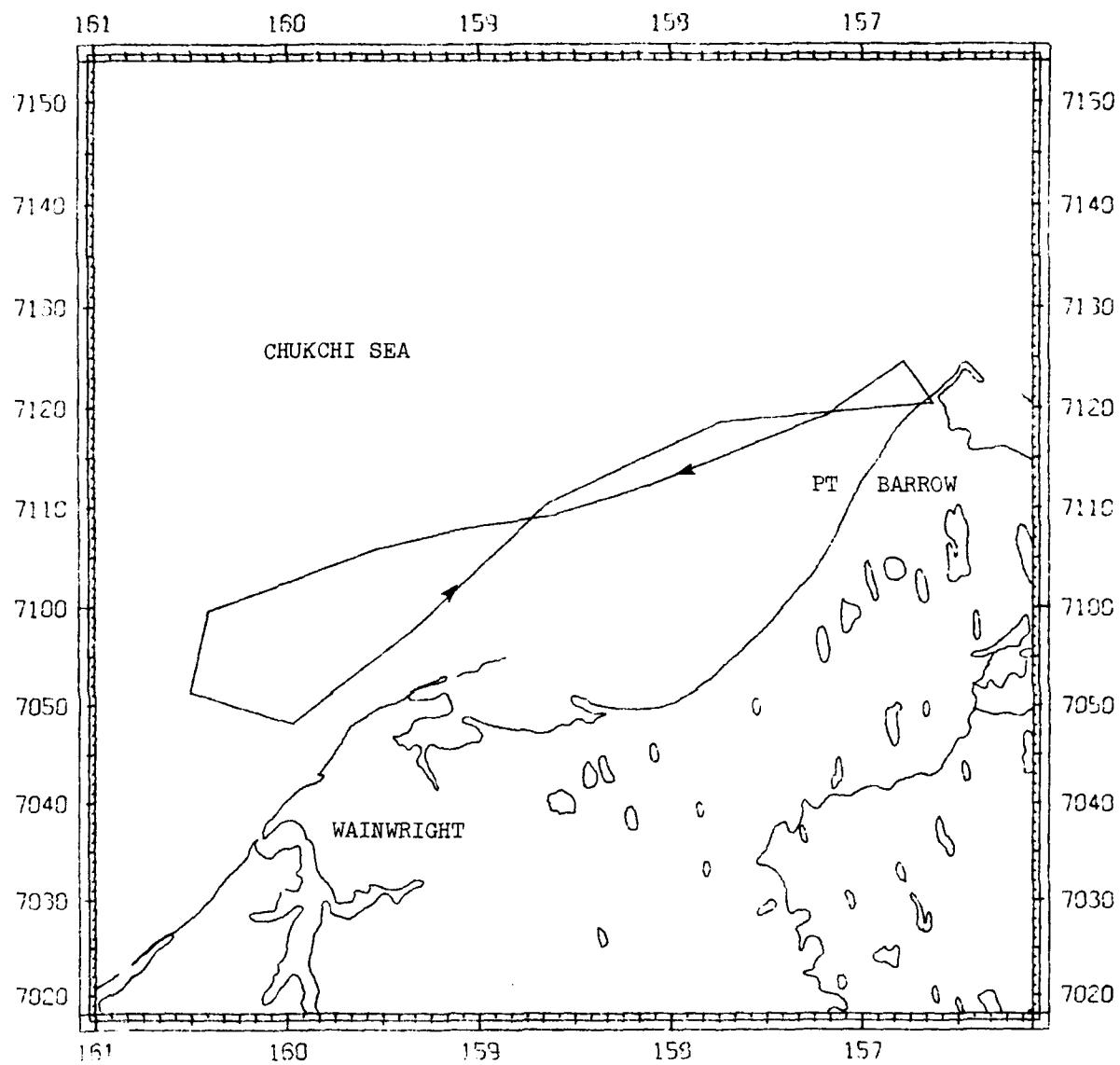
NL





FLIGHT 1. 20 April 1980. Flight was northeast of Pt. Barrow. Small polynyas and open water were noted. One female polar bear with 2 small cubs sighted.

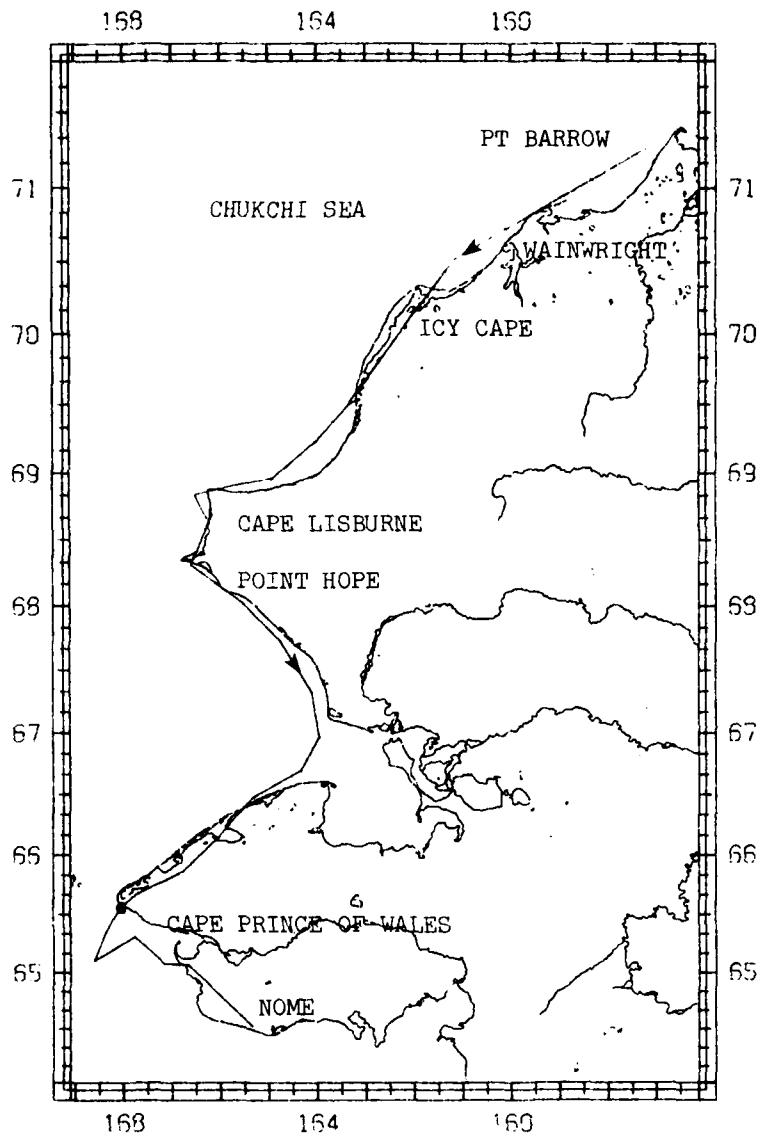
No bowhead sightings for flight 2, 23 April 1980



FLIGHT 2. 23 April 1980. Flight was southwest of Pt. Barrow. One nearshore lead 9 km west of Pt. Barrow was about 10 km long.

Bowhead Whale Sightings for Flight 3, 28 April 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	168-03.4	65-33.3	2000	N-000	
TOTAL 1					

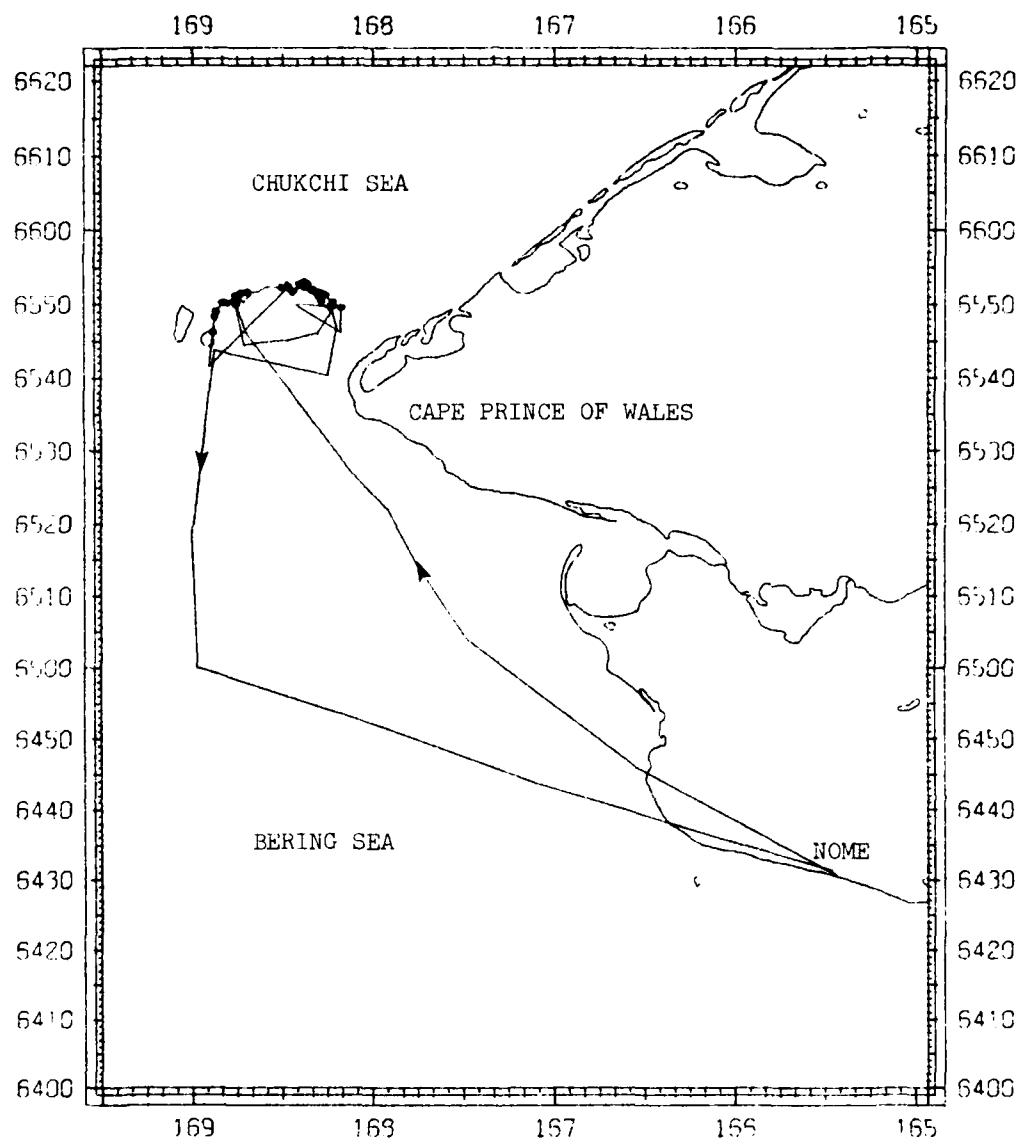


FLIGHT 3. 28 April 1980. Flight was south from Point Barrow to Nome to investigate the delay in the migration. There were continuous nearshore leads from Pt. Hope to Kivalina, with solid ice south of Kivalina to Cape Prince of Wales. The Bering Straits had open water. One bowhead was sighted south of Cape Prince of Wales.

Bowhead Whale Sightings for Flight 4, 29 April 1980

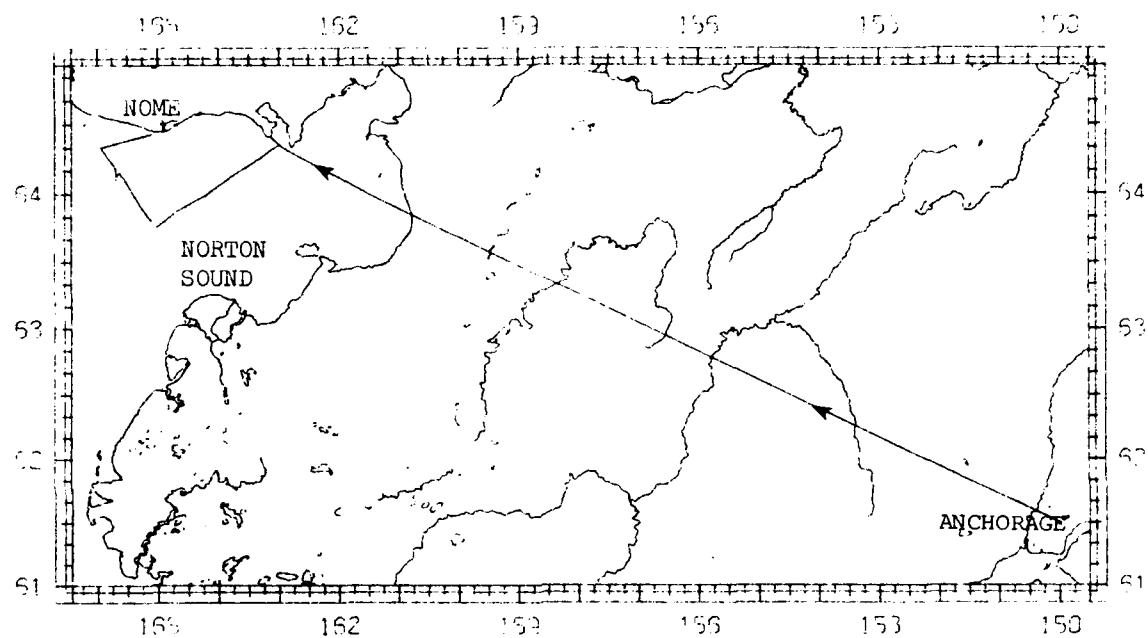
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	168-45.5	65-51.1	120		
1	168-48.5	65-50.0	120	SE-135	
2	168-41.6	65-51.6			Milling on surface
7	168-44.3	65-51.2	120		Milling
2	168-43.9	65-51.5	150	W-270	
1	168-30.3	65-52.2	90		
2	168-27.6	65-52.6	90		
3	168-22.8	65-52.3	90		
2	168-19.7	65-51.9	90		
2	168-18.0	65-51.0	90		
2	168-17.1	65-50.3	90		
2	168-45.4	65-49.9	90		
1	168-45.3	65-50.9	90	NW-315	
1	168-49.7	65-50.1	90		
2	168-52.6	65-48.2	90		
1	168-53.1	65-46.1	90		
1	168-28.2	65-52.4	100	E-090	
1	168-26.7	65-51.6			
9	168-24.5	65-52.6			Seen in pan ice
2	168-23.5	65-52.8			
3	168-22.5	65-52.7			
1	168-21.6	65-52.5			
3	168-22.0	65-52.2			
5	168-20.2	65-51.8			
8	168-19.3	65-51.7			
8	168-17.3	65-51.5			
2	168-15.6	65-51.2			
1	168-13.2	65-50.2			
4	168-10.5	65-49.4			
3	168-13.8	65-49.7			Lying still, flippers out of water

TOTAL 89



FLIGHT 4. 29 April 1980. Flight was to the Bering Straits. Eighty-nine bowheads, 75 belugas, 6 walruses, and 1 polar bear were sighted along or within 2 km of the ice edge. One 15-meter bowhead which had a bleeding back wound was sighted near Little Diomede. Two sonobuoys were dropped and recordings were made of ambient noise. Belugas were sighted at Cape Darby when the aircraft flew west to east over Norton Sound enroute to Anchorage.

No bowhead sightings for flight 5, 2 May 1980

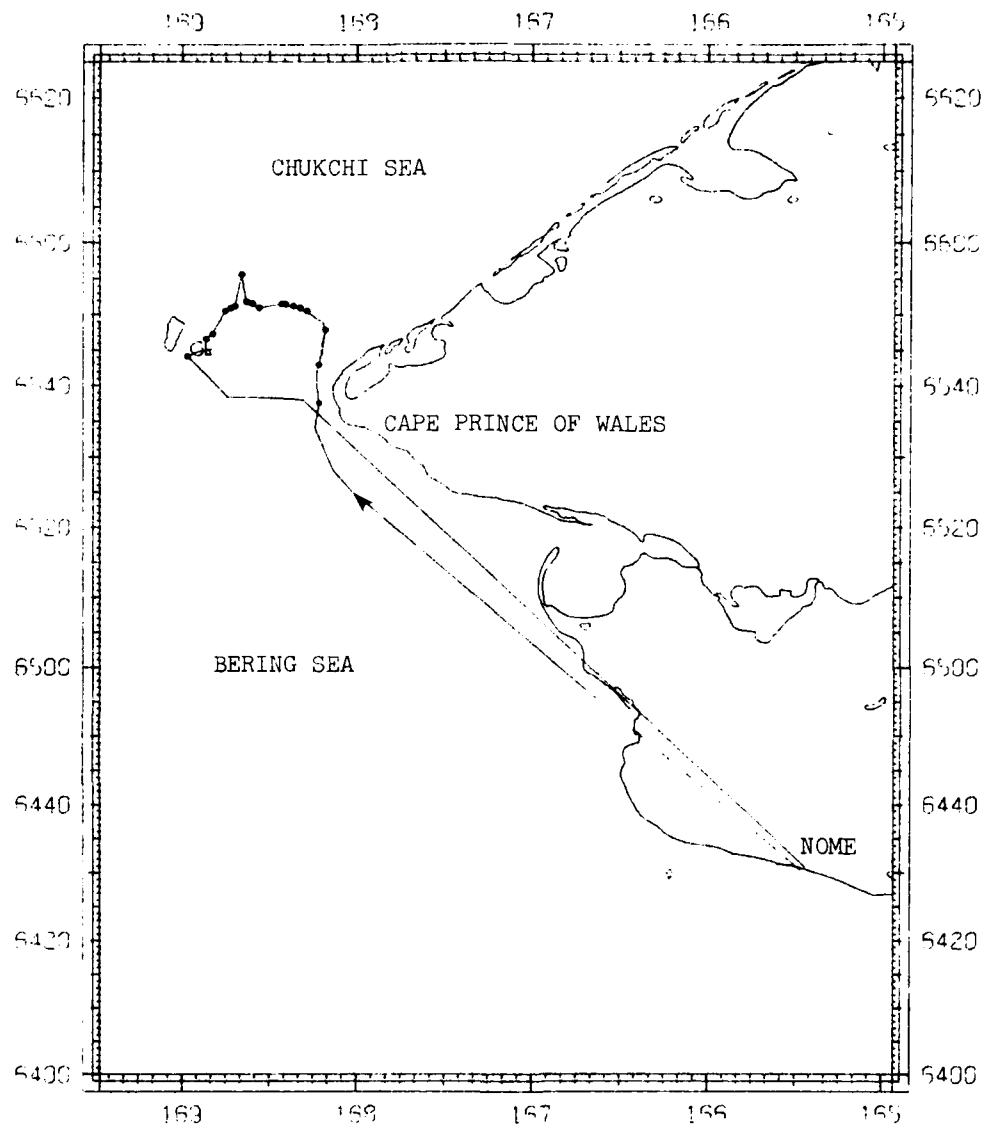


FLIGHT 5. 2 May 1980. Flight was enroute from Anchorage to Nome. Flew transects of Norton Sound east to west. Sighted 9 walruses and 3 ring seals.

Bowhead Whale Sightings for Flight 6, 2 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	168-12.9	65-37.5	350	NW-330	Breaching
1	168-13.0	65-42.9	350	N-360	
12	168-10.8	65-47.8	350		
1	168-17.1	65-50.4	350		
1	168-19.5	65-50.9	350		
5	168-21.8	65-51.1	350	N-360	
4	168-24.5	65-51.4	350		
3	168-25.8	65-51.4	350		At ice edge
20	168-33.5	65-50.9	300		
2	168-35.8	65-51.5	300		
21	168-37.8	65-51.7	300		
1	168-39.4	65-55.5	300		
1	168-41.8	65-51.1	300		Breaching
2	168-43.2	65-50.9	300		Breaching
3	168-45.1	65-50.4	300		
1	168-49.5	65-49.2	300		
2	168-51.8	65-46.5	300		
3	168-14.9	65-45.7	120		Milling in grease ice
2	168-58.2	65-44.1	120		

TOTAL 85

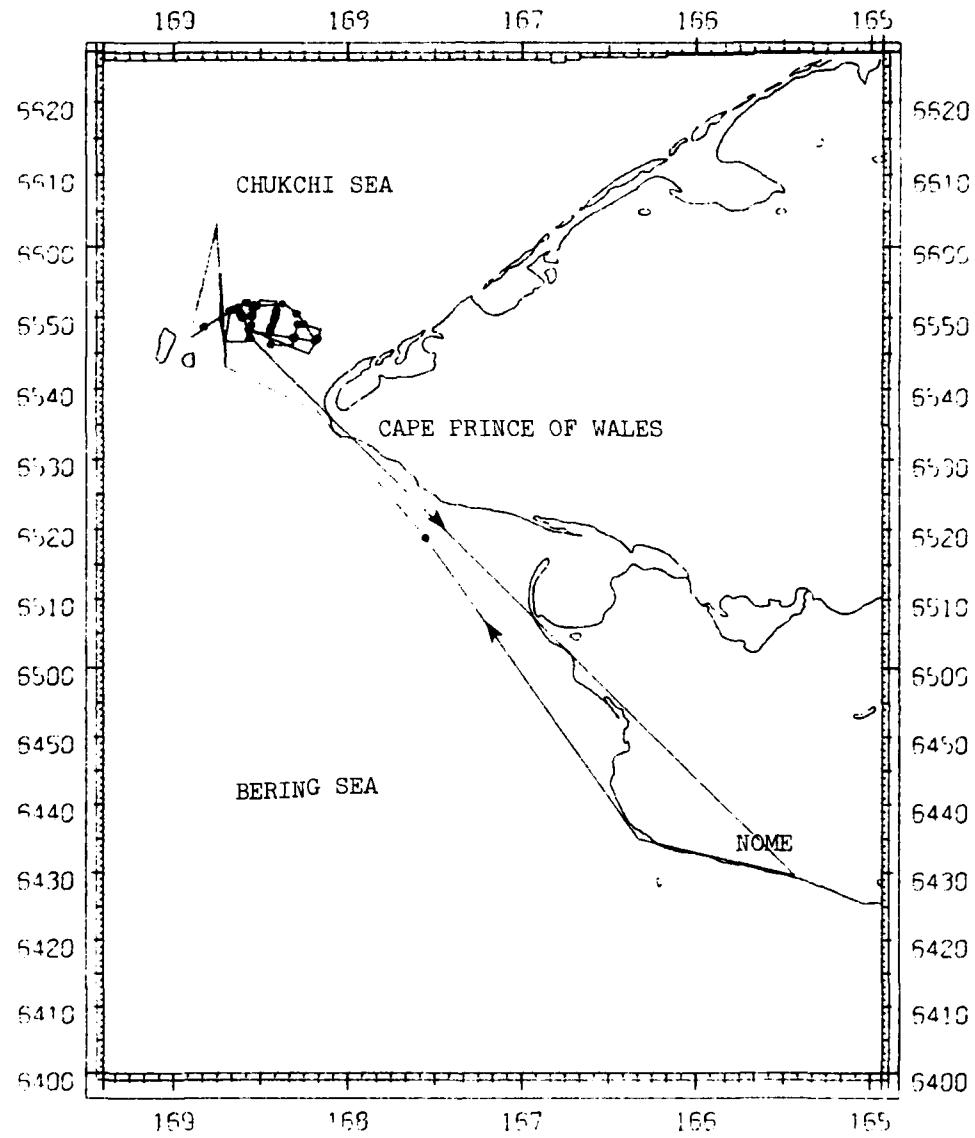


FLIGHT 6. 2 May 1980. Flew from Nome to the Bering Straits. Sighted 85 bowheads in groups of 3 to 7. There was no response to the aircraft. Six whales were sighted in the pan ice 2 km south of the ice edge. Several sonobuoys were dropped and ambient levels were recorded. Four walruses and 237 belugas were also sighted.

Bowhead Whale Sightings for Flight 7, 8 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
2	167-33.2	65-19.9	300	SE-135	Side by side
2	168-49.6	65-49.9	300		
2	168-39.5	65-52.3	300		
1	168-37.9	65-52.6	300		
1	168-35.0	65-53.3	300		Lying still
1	168-32.4	65-52.9	300		
5	168-31.4	65-52.8	300		
2	168-22.6	65-53.1	300		
2	168-17.6	65-51.7	300		
12	168-11.5	65-47.9	300		
1	168-34.2	65-49.4	300		
9	168-10.6	65-48.2	300		3 groups
3	168-15.3	65-50.3	300		
40	168-17.4	65-50.2	300		10 groups
2	168-18.4	65-48.4	300		
5	168-18.5	65-48.3	300		
4	168-18.6	65-48.2	300		
2	168-26.5	65-47.4	300		
1	168-27.3	65-48.8	300		
1	168-26.7	65-49.3	300		
2	168-26.0	65-50.1	300		
4	168-25.5	65-50.8	300		
3	168-25.2	65-51.1	300		
3	168-24.8	65-51.7	300		
1	168-24.6	65-52.3	300		
1	168-32.8	65-52.4	300		
1	168-33.0	65-51.6	300		
2	168-33.1	65-51.4	300		
1	168-33.4	65-50.1	300		
1	168-34.0	65-49.4	300		
1	168-36.5	65-51.4	300		
1	168-36.3	65-51.2	300		
2	168-33.5	65-48.2	300		

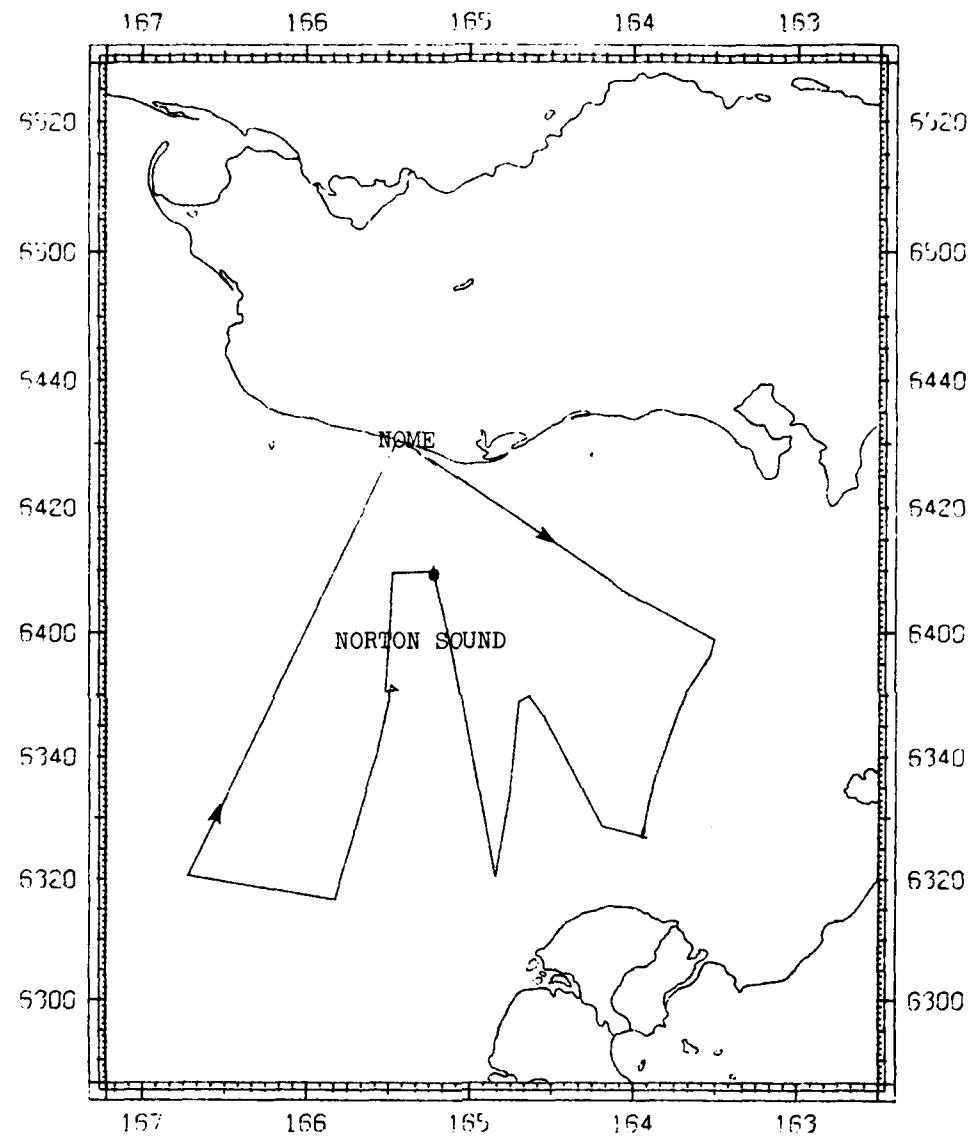
TOTAL 121



FLIGHT 7. 8 May 1980. Flight was to the Bering Straits, east along the ice edge. Sighted over 1000 walruses. Flew north-south transects between Cape Prince of Wales and Little Diomede Island and counted 121 bowheads. Dropped sonobuoys and recorded ambient level.

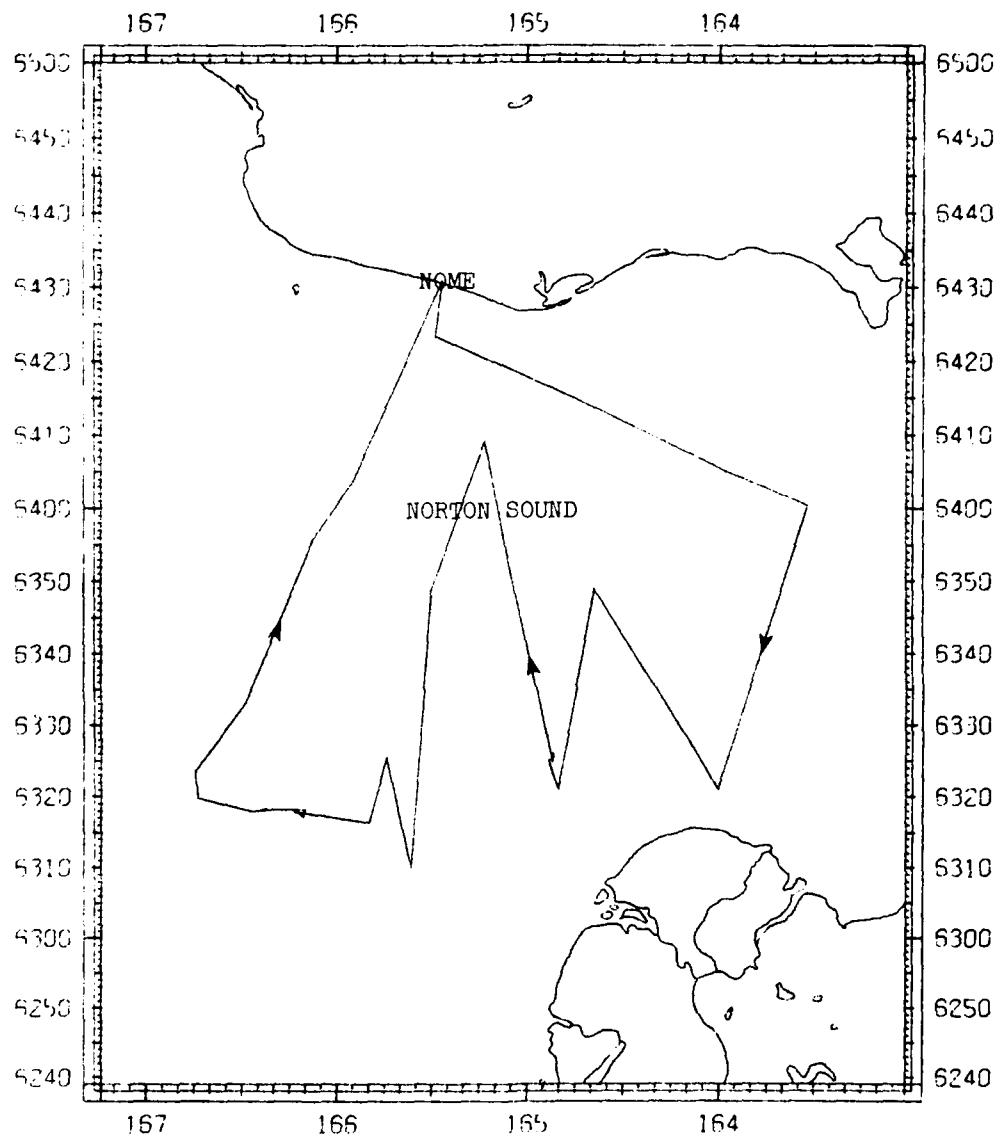
Bowhead Whale Sightings for Flight 8, 8 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	165-13.0	64-09.2	350	SE-135	8 meters long
TOTAL 1					



FLIGHT 8. 8 May 1980. Flight included the proposed Norton Sound lease area. Ice was 6/10. One bowhead, 60 belugas, 3 ring seals, and 6 walruses were sighted.

No bowhead sightings for flight 9, 12 May 1980

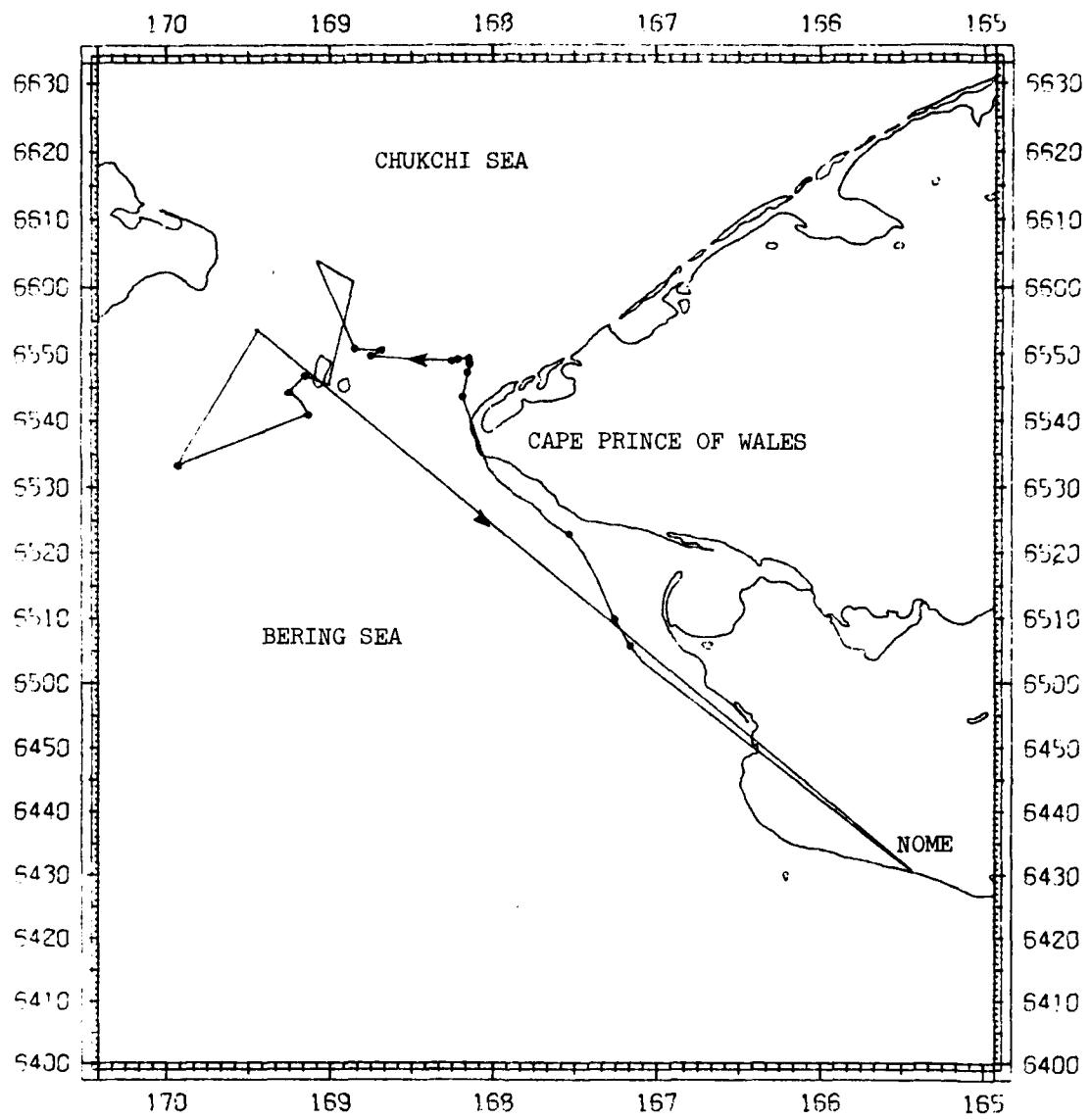


FLIGHT 9. 12 May 1980. Flight included Norton Sound lease area.
Sighted 23 belugas, 51 walruses, and 1 ring seal.

Bowhead Whale Sightings for Flight 10, 13 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	167-09.5	65-05.7	600	S-180	12 meters long
1	167-15.2	65-09.8	300	S-180	
1	167-31.8	65-22.7	300	S-180	
2	168-11.0	65-43.5	300		
1	168-09.1	65-47.1	300		
1	168-08.2	65-48.4	300		
5	168-08.5	65-49.2	300		
1	168-12.6	65-49.1	300		
3	168-14.8	65-48.9	300		
38	168-44.8	65-49.6	300		Cluster
6	168-40.8	65-50.5	300		
6	168-50.7	65-50.7	300		In lead
2	169-08.9	65-46.7	300		
1	169-14.9	65-44.2	300		
2	169-07.8	65-40.8	300		
2	168-55.6	65-33.2	300		

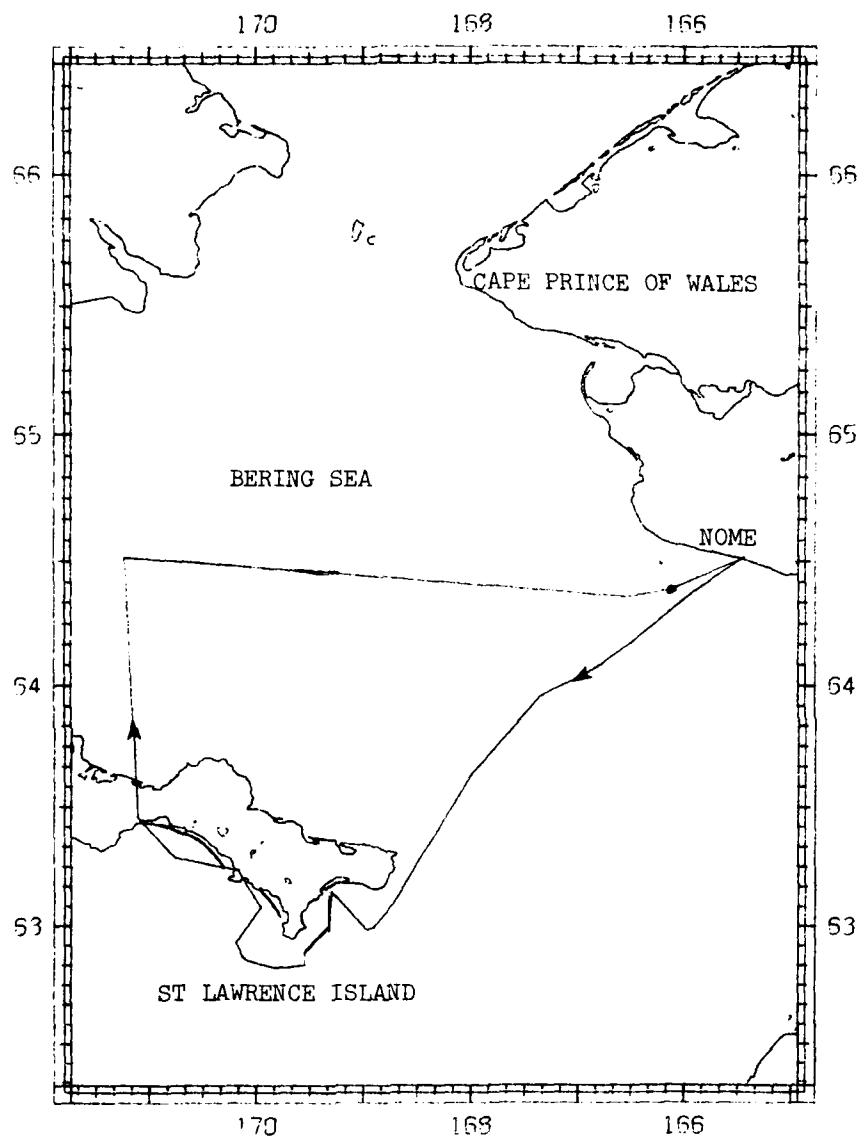
TOTAL 73



FLIGHT 10. 13 May 1980. Flight was from Nome to the Bering Straits. Three bowheads were sighted in the Pt. Clarence area, all heading south. Ice coverage was decreasing. Many bowheads lying very still next to the ice edge were sighted 5 km from Little Diomede Island. Two types of sounds were recorded. There was no reaction to the aircraft. Sighted 73 bowheads; most were 12 m and one was tan or mottled brown. One hundred fifty belugas and 72 walruses were also in the area.

Bowhead Whale Sightings for Flight 11, 14 May 1980

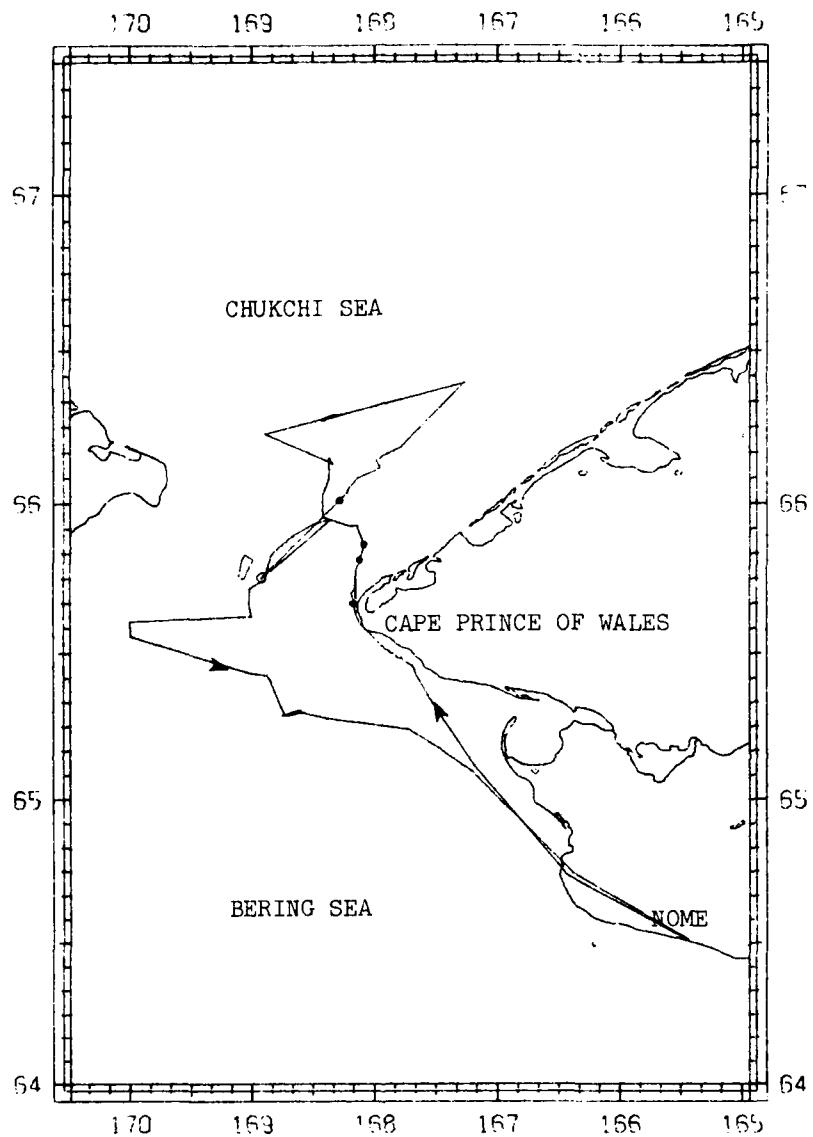
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
2	166-07.6	64-23.1		SE-135	
1	166-07.4	64-23.3			
TOTAL 3					



FLIGHT 11. 14 May 1980. Flight was to St. Lawrence Island. Sighted 3 bowheads. Eight bearded seals and 717 walruses were also sighted. Flight restricted by severe weather conditions.

Bowhead Whale Sightings for Flight 12, 15 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	168-09.5	65-40.0			Dove
1	168-16.4	66-00.5			In small crack large enough for head and front third of body
2	168-07.1	65-48.7			
1	168-04.8	65-51.8			
TOTAL 5					

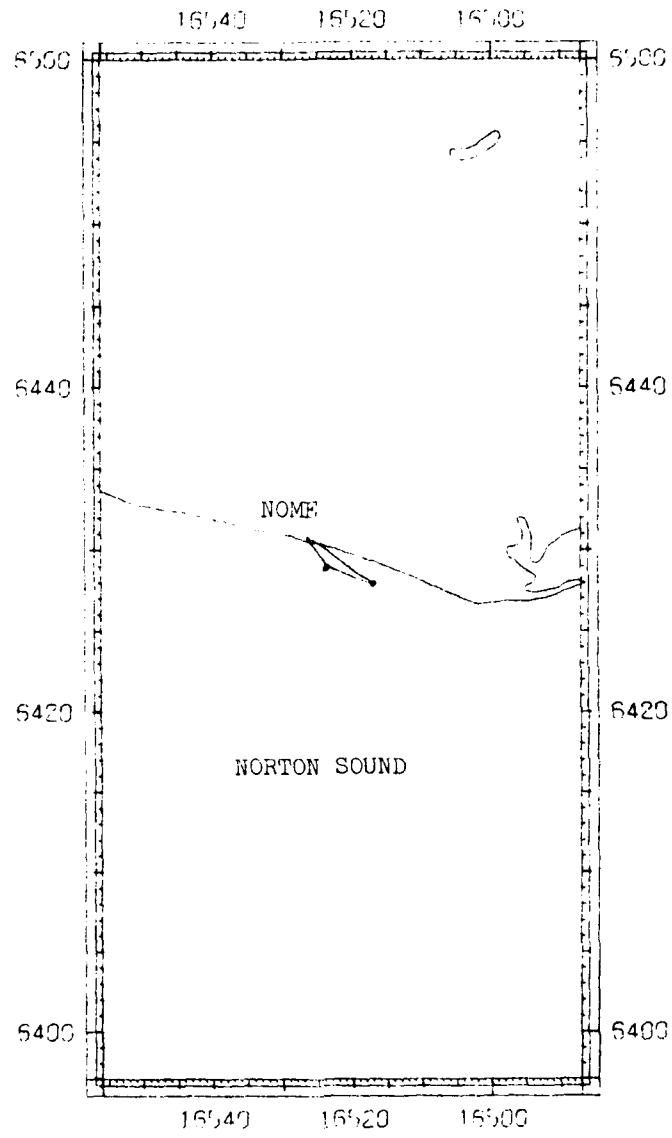


FLIGHT 12. 15 May 1980. Flight was to the Bering Straits. Ice conditions were changing. The migration appeared to have started. A small 30-m wide lead northeast from Wales contained 2 bowheads. Three other bowheads were sighted lying still in small polynyas north of the Diomedes. Sighted 364 walruses, 22 bearded seals, 6 ring seals, and 698 belugas.

No bowhead sightings for flight 13, 18 May 1980

Gray Whale Sightings for Flight 13, 18 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
3	165-26.5	64-30.8	300
3	165-17.3	64-27.9	300
TOTAL 6			

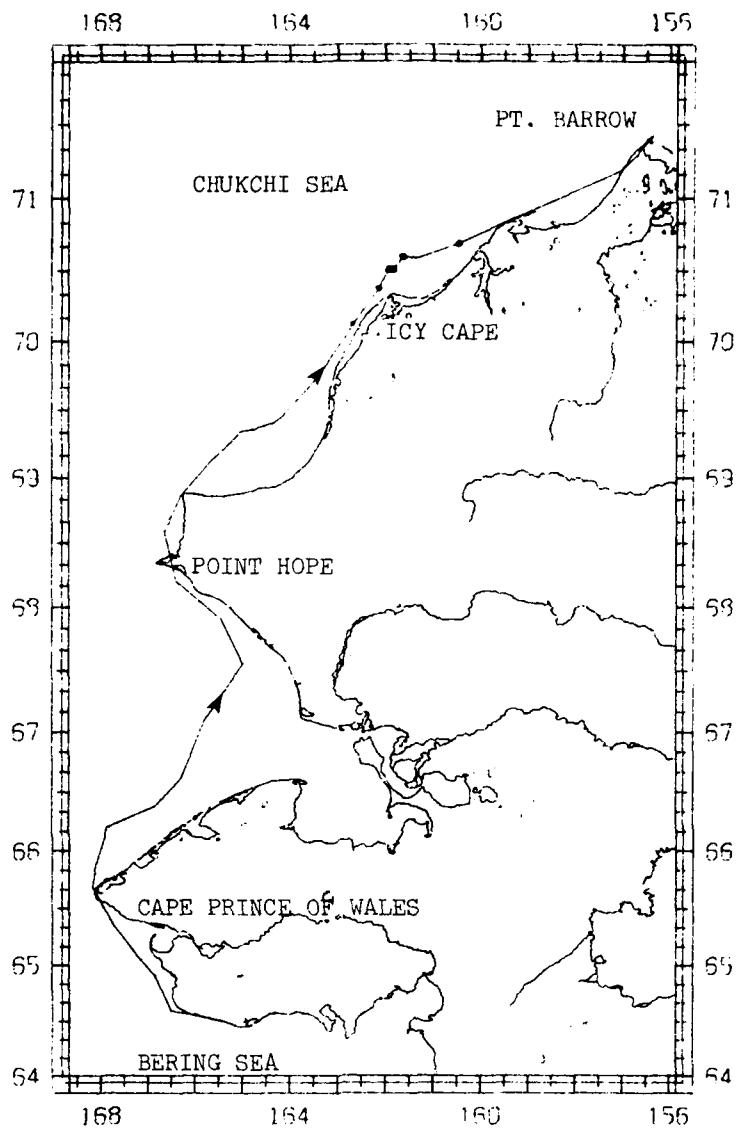


FLIGHT 13. 18 May 1980. Near coast by Nome over muddy river runoff, 6 gray whales were sighted within 1 km of the beach.

Bowhead Whale Sightings for Flight 14, 20 May 1980

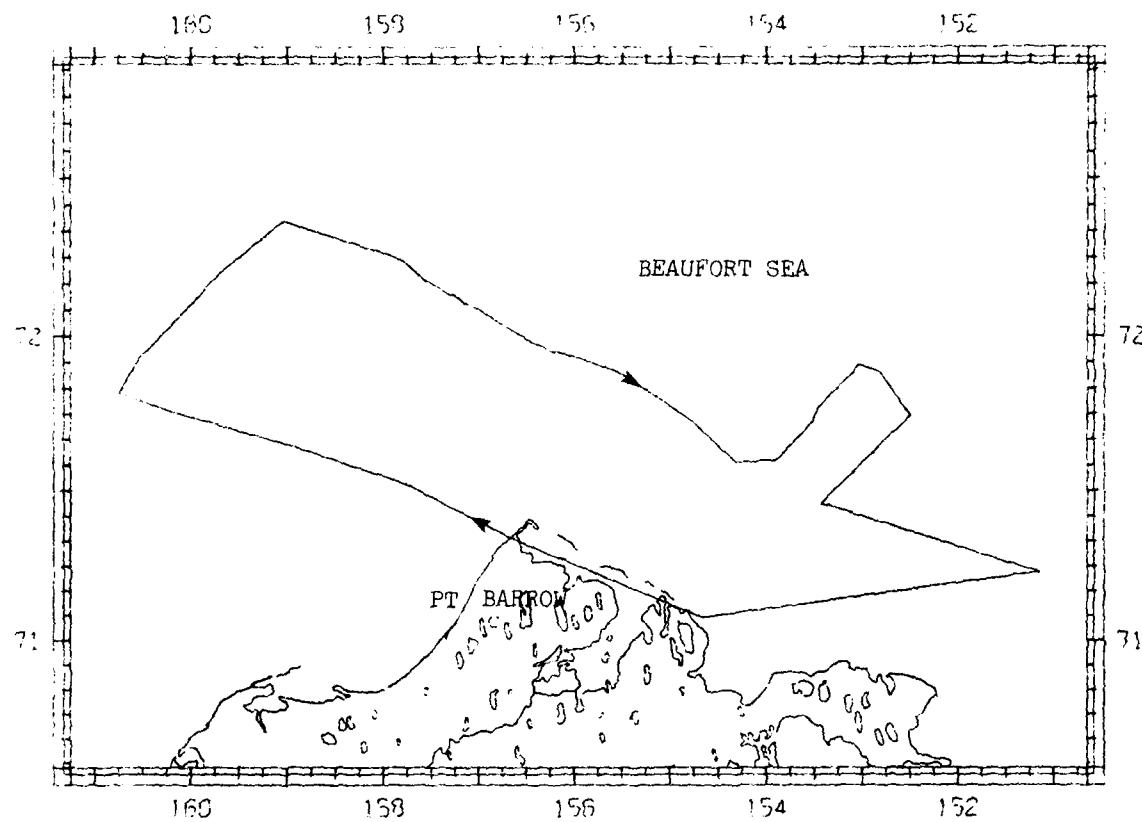
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
2	162-40.8	70-07.6	350	NE-045	
1	162-09.2	70-22.7	270	NE-045	Dove
1	161-55.1	70-30.8	250	NE-045	Dove
1	161-50.5	70-30.6	250	NE-045	Dove
1	161-38.0	70-36.1	250	NE-045	Dove
1	160-27.7	70-41.6	270	NE-045	Dove, in grease ice

TOTAL 7



FLIGHT 14. 20 May 1980. Flight was north from Nome to Point Barrow. Sighted 119 belugas from Nome to the Bering Straits. Flew the coastal leads from Kivalina to Point Barrow. Seven bowheads were sighted south of Wainwright. All were heading northeast.

No bowhead sightings for flight 15, 21 May 1980

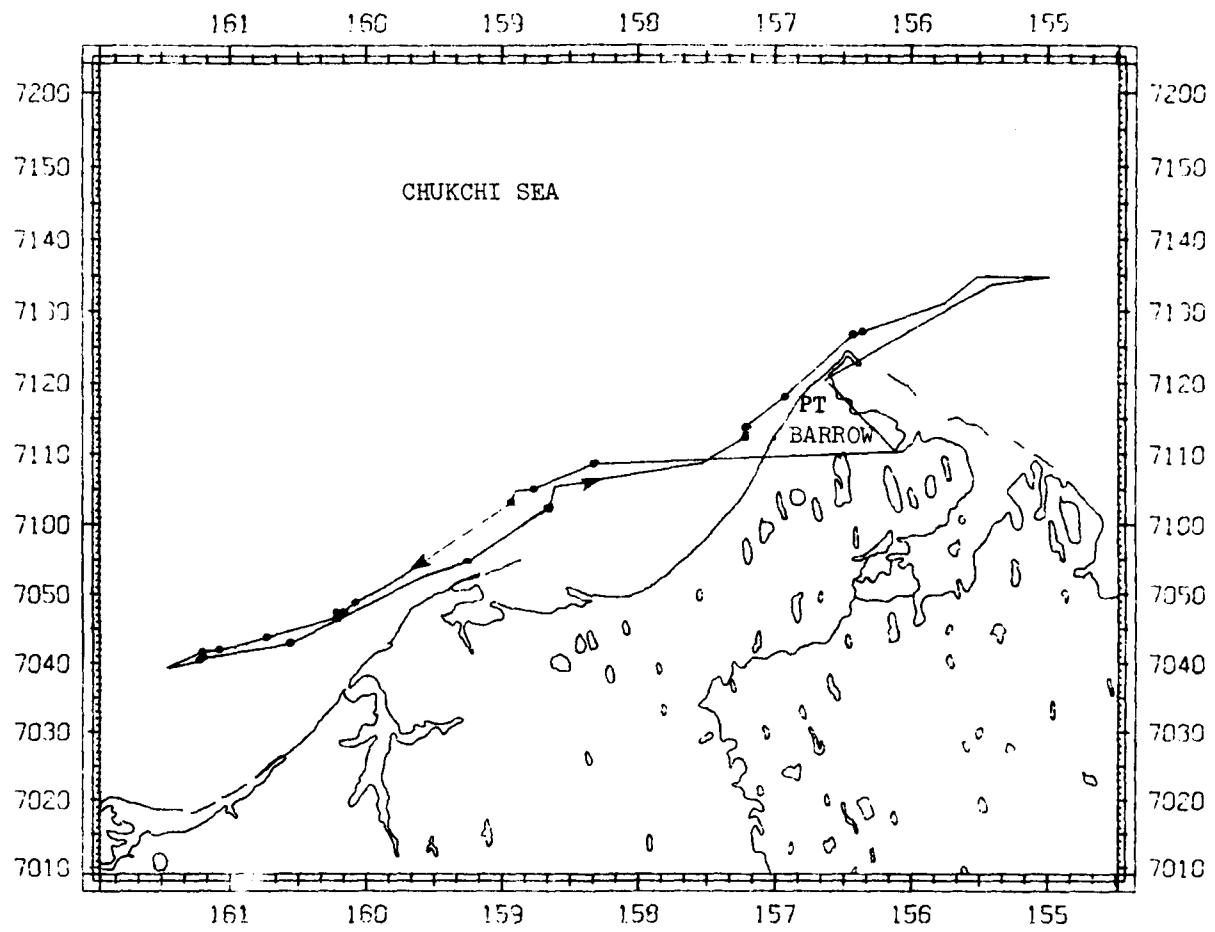


FLIGHT 15. 21 May 1980. Flight covered the vicinity north of Pt. Barrow. Sighted 1 small unidentified whale heading northeast in small polynyas. Two belugas and 21 bearded seals were sighted.

Bowhead Whale Sightings for Flight 16, 22 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	158-19.6	71-08.4	180	NE-045	2-3 kn speed, dove immediately
3	158-46.3	71-04.9	180	NE-045	Close group, dove
2	158-53.6	71-04.6	240	NE-045	
2	158-56.1	71-03.0	180	NE-045	
2	158-25.4	70-56.5	180	NE-045	
1	158-76.2	70-34.3	120		
3	158-27.8	70-54.7	150	NE-045	12 meters long
2	158-26.1	70-54.1	150		No response to aircraft
3	160-04.9	70-48.6	150	NE-045	
2	160-10.2	70-47.3	150	NE-045	
2	160-13.4	70-47.3	210	NE-045	
1	160-13.3	70-46.4	180		
1	160-44.1	70-43.6	210	NE-045	Swimming shallow
3	161-04.7	70-41.8	210	NE-045	Dove
3	161-12.2	70-41.5	180	NE-045	Dove, pair an' single
2	161-13.3	70-40.3	150	NE-045	Swimming just below surface, no response
1	161-11.6	70-40.7	120	NE-045	Swimming just below surface
2	160-33.7	70-42.8	180	NE-045	
1	159-27.2	70-54.5	180	NE-045	On surface, no response
1	158-40.2	71-02.2	150	NE-045	Swimming on surface
1	158-39.1	71-02.2	170	NE-045	7 meters long, swimming on surface
1	157-13.4	71-12.3	150	NE-045	Dove
1	157-12.8	71-13.8	170	NE-045	Swimming on surface
1	156-56.0	71-18.0	170	NE-045	Moving rapidly, 0.25 km from shore
1	156-26.0	71-26.7	150		
1	157-21.6	71-27.1			

TOTAL 44

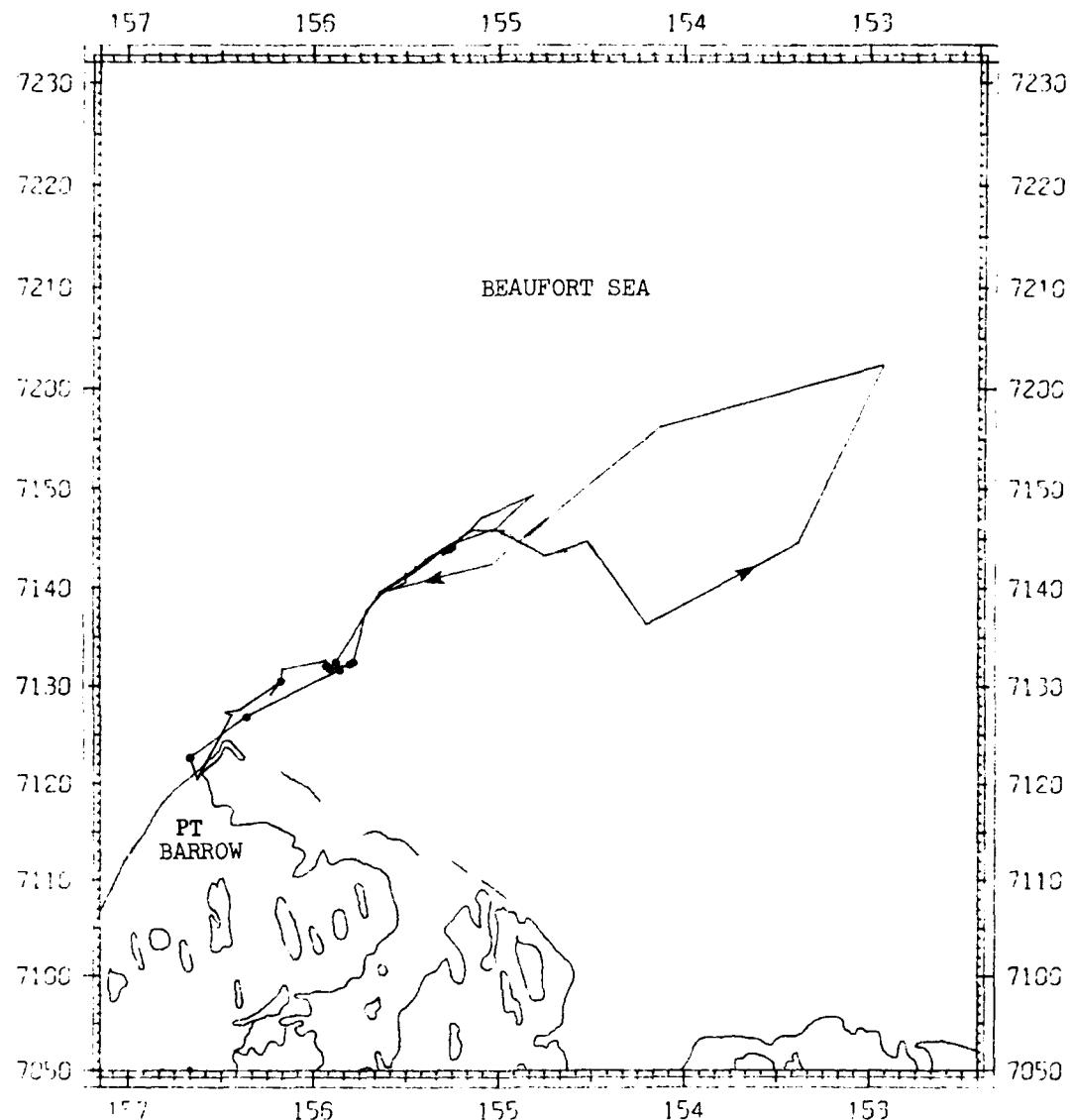


FLIGHT 16. 22 May 1980. Flight was 65 km south of Wainwright.
 Sighted 44 bowheads mostly near the offshore edge of the coastal lead.
 Sighted 57 belugas and 4 bearded seals.

Bowhead Whale Sightings for Flight 17, 23 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	156-10.4	71-30.5	120		{
2	155-55.6	71-32.0	150	NE-040	Dove
1	155-54.5	71-31.8	150	NE-030	8 meters long
1	155-48.0	71-32.2	180	NE-020	
1	155-46.9	71-32.4	120		Blew, dove
1	155-52.5	71-32.4	120		
3	155-51.2	71-31.6	150		15, 12 and 10 meters long, possible resighting
1	156-24.8	71-76.8	170		1 breath every 15 seconds
1	156-40.0	71-22.6			

TOTAL 12

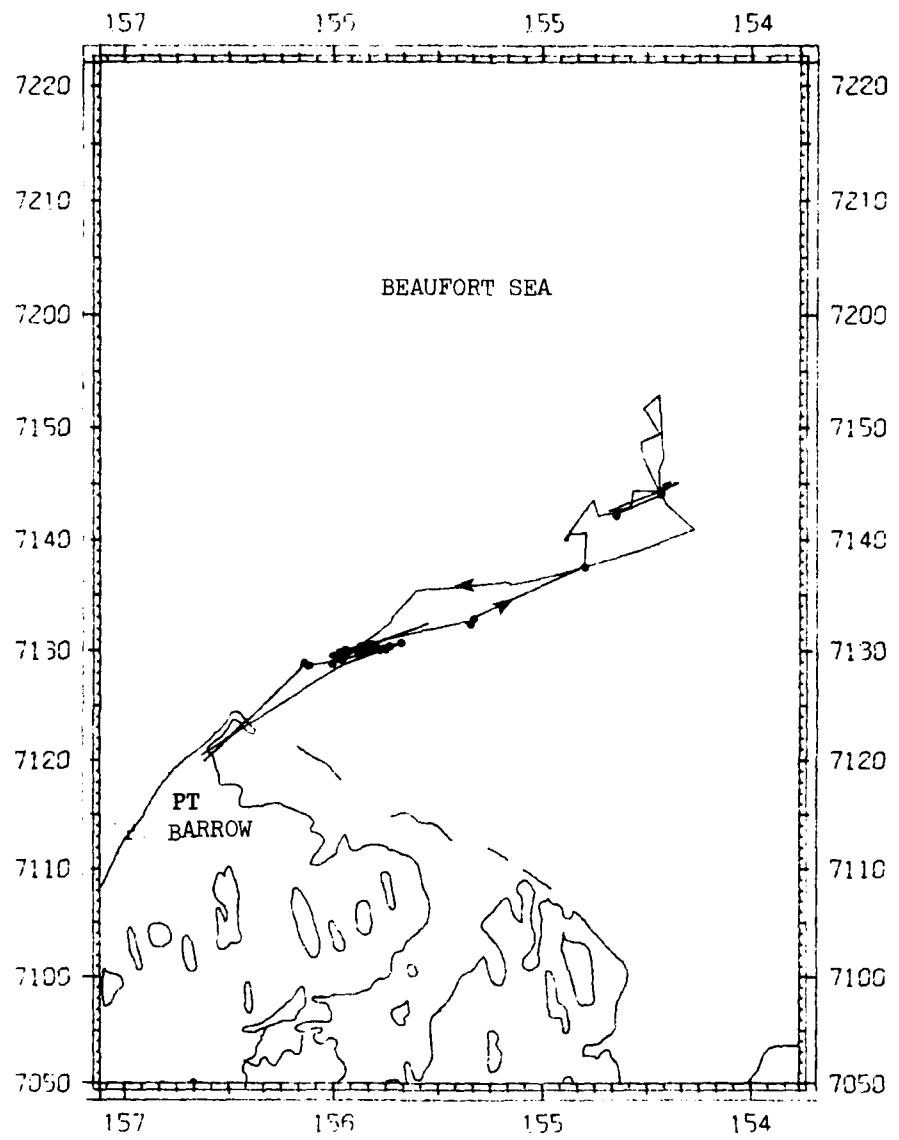


FLIGHT 17. 23 May 1980. Flight was northeast of Pt. Barrow. Twelve bowheads were sighted, as well as 479 belugas, 2 bearded seals, and 4 polar bears.

Bowhead Whale Sighting: for flight 18, 24 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	156-08.6	71-28.9	150	NE-045	Dove
1	156-07.1	71-28.7	150	NE-045	Dove
1	155-57.6	71-29.2	150	NE-045	On surface, swimming in 30-meter wide lead, dove
3	154-26.2	71-44.1	120	NE-000	
2	152-24.6	71-44.9	150	NE-000	Resighting
2	154-38.9	71-42.2	170	NE-045	In 30-meter wide lead
1	154-48.0	71-37.6	60	NE-060	Dove under large ice mass
1	154-20.0	71-32.9	60		On surface
1	154-20.9	71-32.4	120		
1	155-52.2	71-30.4	150		
2	155-53.1	71-30.1	180		White "V" on tail stock, no response to aircraft
3	154-47.7	71-40.6			
1	155-52.6	71-30.2			
5	155-53.0	71-29.7	90		No response to aircraft
1	155-48.1	71-30.4	90		
1	155-44.0	71-30.4	120		Resighting
5	155-47.0	71-30.1	120		
1	156-00.4	71-28.8	120		
2	155-58.1	71-29.9	60		10 and 12 meters long
1	155-56.6	71-30.1	60		Dove
4	155-49.1	71-30.6	90		
1	155-58.0	71-29.4	90		
1	156-00.0	71-29.6	60		
1	155-51.9	71-30.4	90		On surface
1	155-45.4	71-30.1	90		13-14 meters long, dove
2	155-40.6	71-30.7	60		

TOTAL 46

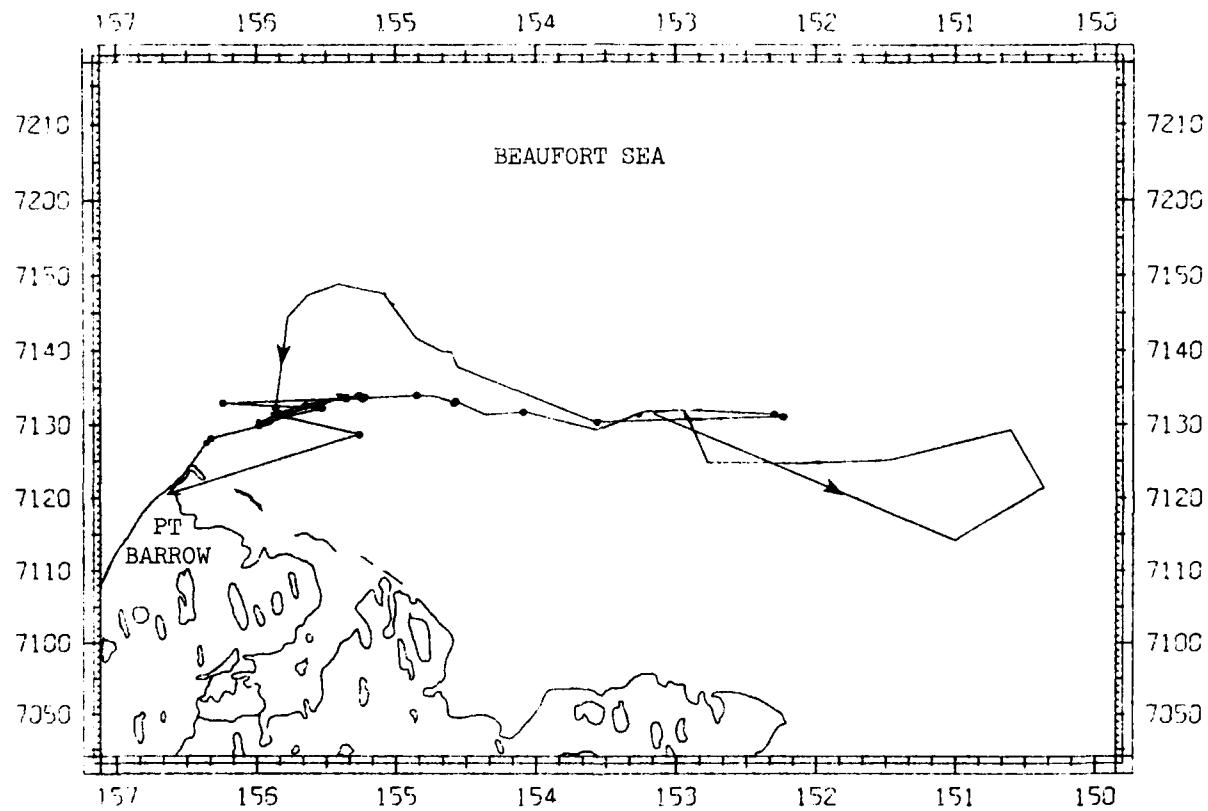


FLIGHT 18. 24 May 1980. Flew northeast of Pt. Barrow. Sighted 46 bowheads in narrow leads. No whales seen in large leads and polynyas. Sighted 474 belugas and 4 bearded seals.

Bowhead Whale Sightings for Flight 19, 25 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	156-21.5	71-27.5	90		12 meters long, dove
4	156-19.6	71-28.1	90		Dove under ice floe
1	155-59.0	71-29.8	90		
1	155-58.2	71-30.1	90		White patch on fluke
1	155-55.4	71-30.3	170		White patch on fluke and head
1	155-54.2	71-30.5	150		Brownish, 8 meters long
1	155-56.8	71-30.2	150		White spots on back
2	155-54.6	71-30.4	150		Swimming close together
1	155-46.6	71-31.2	170		
2	155-31.8	71-32.2	170		Swimming submerged, side by side
1	155-24.3	71-32.9	170		No reaction, swimming just below surface
1	154-50.9	71-33.9	170		
1	154-34.8	71-32.9	170		In small polynya, 9/10 ice, dove
1	154-34.3	71-33.1	170		Going under ice
1	154-05.2	71-31.7	150		Broken lead area
1	153-15.8	71-31.5	180		Swimming on back, white chin patch up
1	153-17.9	71-31.4			Possible resighting
1	153-13.9	71-31.1		SE-150	13 meters long
1	153-33.6	71-30.3		NE-050	
2	155-51.9	71-32.2			Dove, white "V" on stock
2	155-50.7	71-31.5		NE-060	Near ice floe
1	155-46.6	71-31.6		NE-060	
2	155-33.3	71-32.7		NE-060	Both 13 meters long, small white tail patch on one
3	155-23.4	71-33.7		NE-060	Possible calf
1	155-21.2	71-33.7			Submerged
2	155-15.8	71-33.9			
2	155-13.3	71-33.7			White "V" on tail pointing towards head on one
2	155-14.3	71-33.5			Both 13 meters long
3	155-39.0	71-32.6			Dove under ice
2	155-39.0	71-32.6			Possible resighting
1	155-51.0	71-31.4			
1	155-52.1	71-31.3			Dove
1	156-15.6	71-28.6			
2	155-21.4	71-33.5			

TOTAL 51

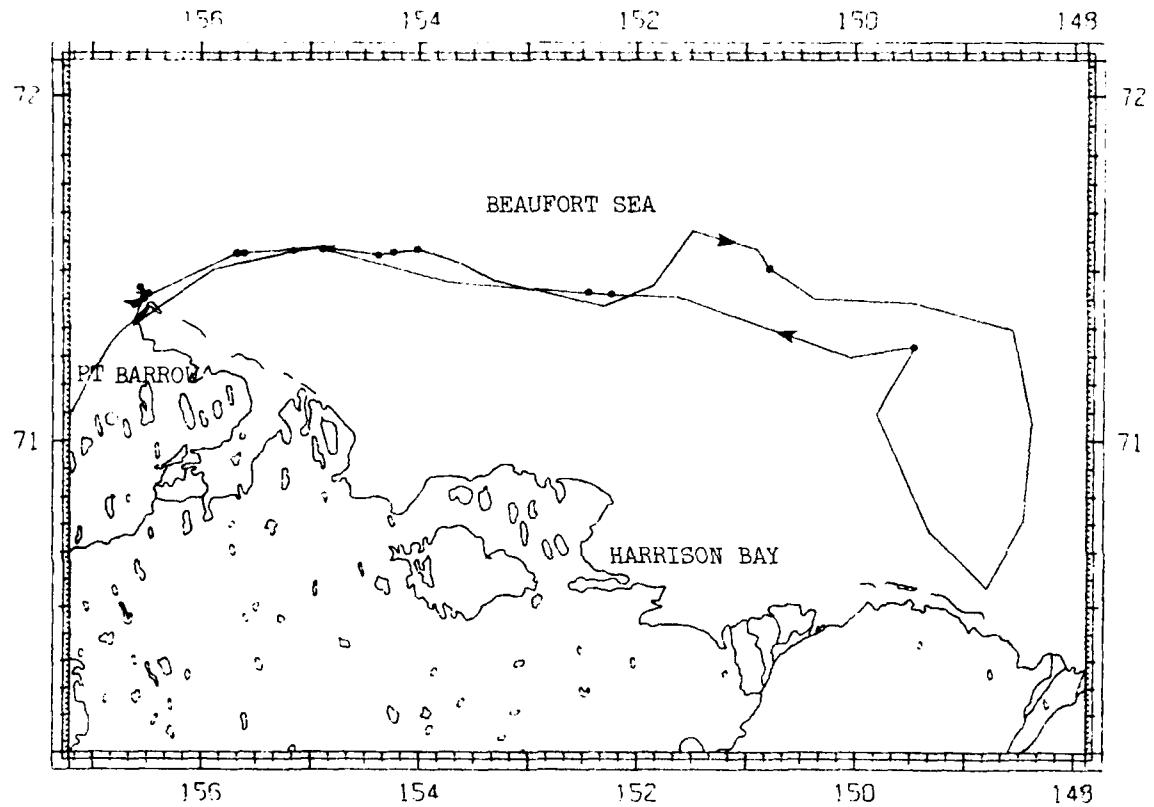


FLIGHT 19. 25 May 1980. Flew east to longitude 151° W. Fifty-one bowheads were sighted in less than an hour. They were sighted in large pan ice and loose ice instead of in the larger leads. Also sighted 149 belugas and 4 bearded seals.

Bowhead Whale Sightings for Flight 20, 28 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	155-09.4	71-33.2	120		12 meters long, 9/10 ice
1	154-22.8	71-32.5	150	NE-050	In open lead, dove
1	154-14.5	71-32.9	120	NE-050	Diving under ice floe
1	154-01.1	71-33.5	150	NE-050	Swimming below surface
1	150-47.6	71-32.2	180	NE-040	Dove under ice in reaction to aircraft
1	150-28.0	71-16.5	90	NE-050	Out from under ice, then returned
1	152-14.0	71-25.7			
1	152-26.8	71-25.9			Dove
2	154-53.4	71-33.5			In brash ice, one dove and one blew
1	155-36.4	71-37.8			Dove
1	155-40.4	71-37.8			Open water
1	156-31.5	71-75.1		NE-030	12 meters long, dove
1	156-43.2	71-23.8			Brownish
1	156-36.7	71-21.9			Dove
2	156-29.4	71-25.8			Swimming below surface
1	156-34.1	71-26.9			

TOTAL 18

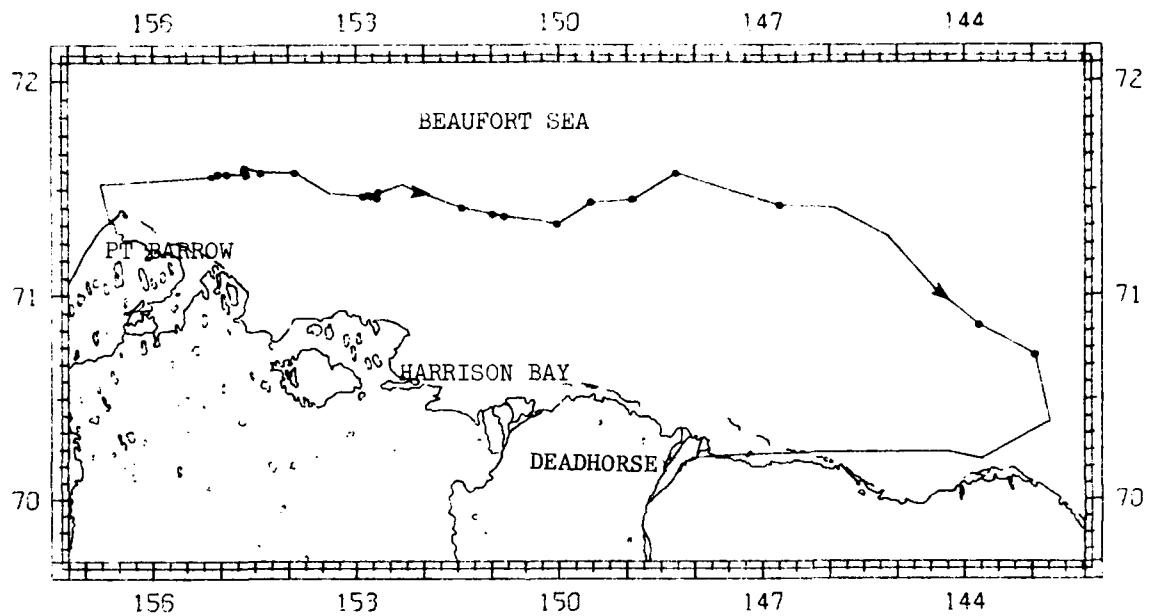


FLIGHT 20. 28 May 1980. Flight was east following the shear line. Sighted 18 whales west to longitude 148° W. Whales were difficult to sight due to ice and diving response to aircraft. Flight covered the perimeter of the Federal Beaufort Sea lease area which was solid ice.

Bowhead Whale Sightings for Flight 21, 28 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	155-07.4	71-33.7	180		14-15 meters long
2	155-07.1	71-34.2	180		14-15 meters long, swimming on surface then dove
1	154-53.8	71-34.4	150		14-15 meters long, 0.8 km from beach
2	154-36.7	71-34.2	150		One with light gray head, swimming close together
1	154-38.4	71-36.0	170		14-15 meters long
2	154-24.2	71-34.7	170	NE-030	Near ice edge, dove
1	153-53.6	71-34.6	180	NE-060	Blew, in small polynya
2	152-53.1	71-28.0	240	NE-060	Swimming on surface, blew
3	152-45.4	71-28.2			Two with white coloration on heads, submerged
1	152-49.1	71-28.4			
3	152-40.4	71-27.5			13-15 meters long, surfaced into small lead
2	152-39.7	71-29.1			14-16 meters long, emerged from ice, dove
1	151-26.1	71-24.9		NE-060	14-15 meters long, went under ice
1	150-58.7	71-23.1			Lying in small polynya, 15 meters long
1	150-48.4	71-22.5			Swimming on surface
1	150-01.7	71-20.3		NE-060	13-15 meters long, dove under ice
1	149-31.3	71-26.4			
1	148-54.5	71-27.2		NE-060	Came up in small hole
1	148-16.5	71-34.5		NE-060	13-15 meters long, in small hole
1	146-44.6	71-25.6		NE-060	12 meters long
1	143-47.3	70-51.5			Came up in small hole, not in the large lead close by

TOTAL 30

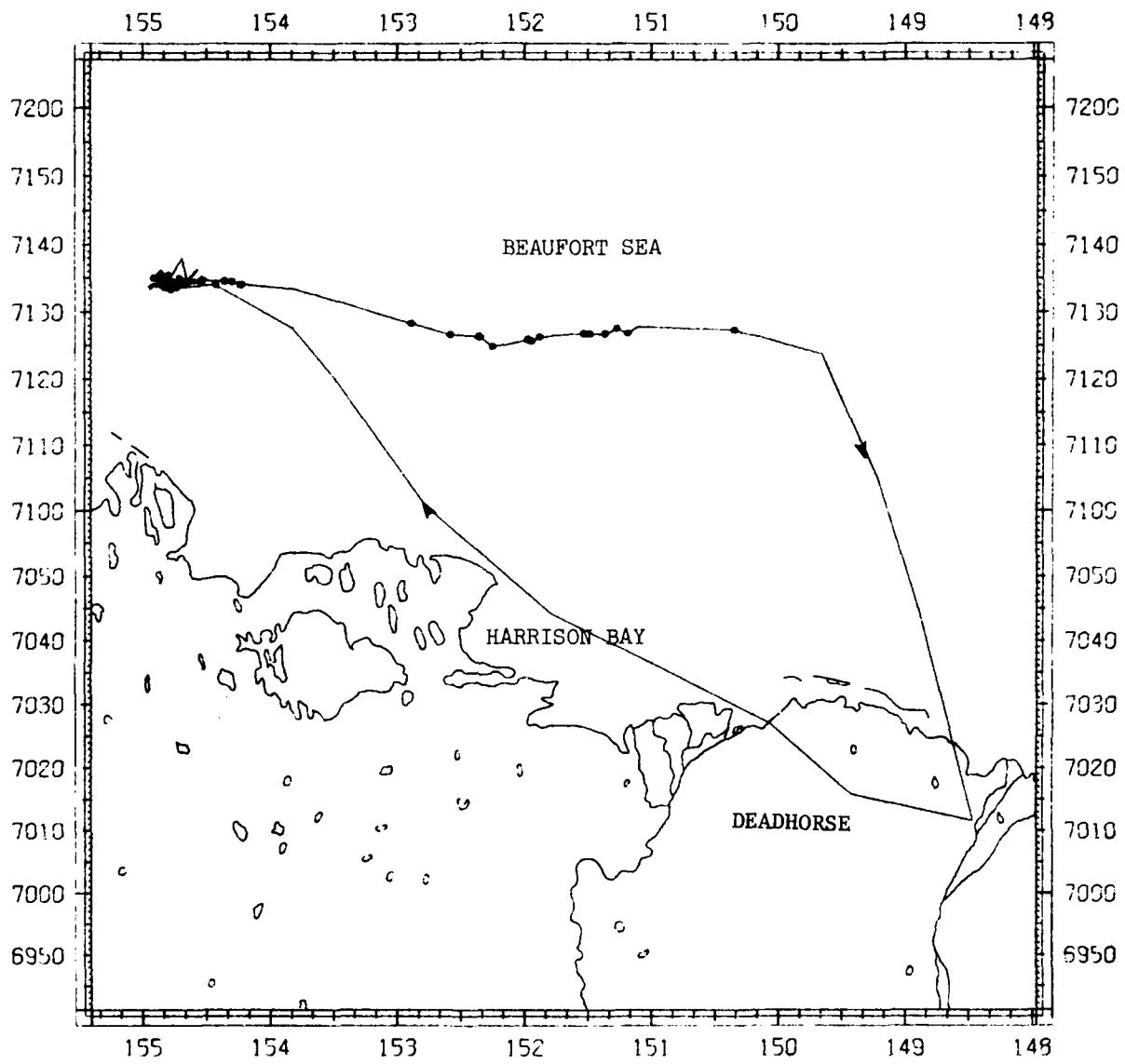


FLIGHT 21. 28 May 1980. Flight east to longitude 144° W. Sighted 30 bowheads and 78 belugas. Most bowheads were headed 060° magnetic.

Bowhead Whale Sightings for Flight 12, 29 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	154-25.9	71-34.1	120		Lying in small hole
2	154-49.4	71-33.7	60		Cow with calf, dove
1	154-46.9	71-33.3	90		In open lead
1	154-50.6	71-34.2	120		At ice edge
2	154-45.4	71-34.6			
2	154-51.5	71-34.6	120		
1	154-50.2	71-35.2	90		Open water
6	154-44.6	71-33.7		NE-050	Group of 3 swimming on surface
2	154-39.6	71-34.4		NE-030	In narrow lead of ice
1	154-49.4	71-33.6			Surfaced and blew
1	154-44.6	71-34.2			Half of head white and tan
1	154-37.6	71-34.5			Dove with fluke straight up
1	154-46.0	71-34.5			Blew
1	154-51.3	71-34.0			Blew
1	154-54.7	71-35.0			
1	154-47.7	71-35.4			Emerged from under ice
2	154-51.7	71-35.6			Went under ice, one smaller
1	154-46.6	71-33.8			Mottled tan and brown coloration on head and brown body, dove
2	154-42.5	71-35.0			Dove under ice
1	154-32.3	71-34.7		NE-060	
1	154-21.7	71-34.6			At ice edge, lying still
2	154-18.3	71-34.5		NE-060	Both with tan coloration on top of head, 14-16 meters long
3	154-14.2	71-34.1			Two with tan coloration on heads, 14-16 meters long
1	153-48.7	71-33.4			
1	152-53.6	71-28.3		NE-060	White coloration on head, dove
1	152-35.0	71-26.6			Dove immediately
2	152-21.8	71-26.3			Both blew and swam on surface, white on base of tail stocks
2	152-15.2	71-24.8			White on flukes
1	151-58.6	71-25.9		NE-070	
2	151-56.9	71-25.7			In ice
1	152-52.9	71-26.3			White marks on sides of tail stock, 14-16 meters long, brown, lying still
2	151-13.2	71-26.8			
1	151-29.4	71-26.7			14-16 meters, brown, lying still
1	151-22.0	71-26.8			Dove then resurfaced
1	151-16.5	71-27.5			
1	151-11.4	71-26.8			Light tan mottling on tail stock, dove
4	151-06.8	71-27.8			At ice edge, all dove, 12-14 meters long

TOTAL 57

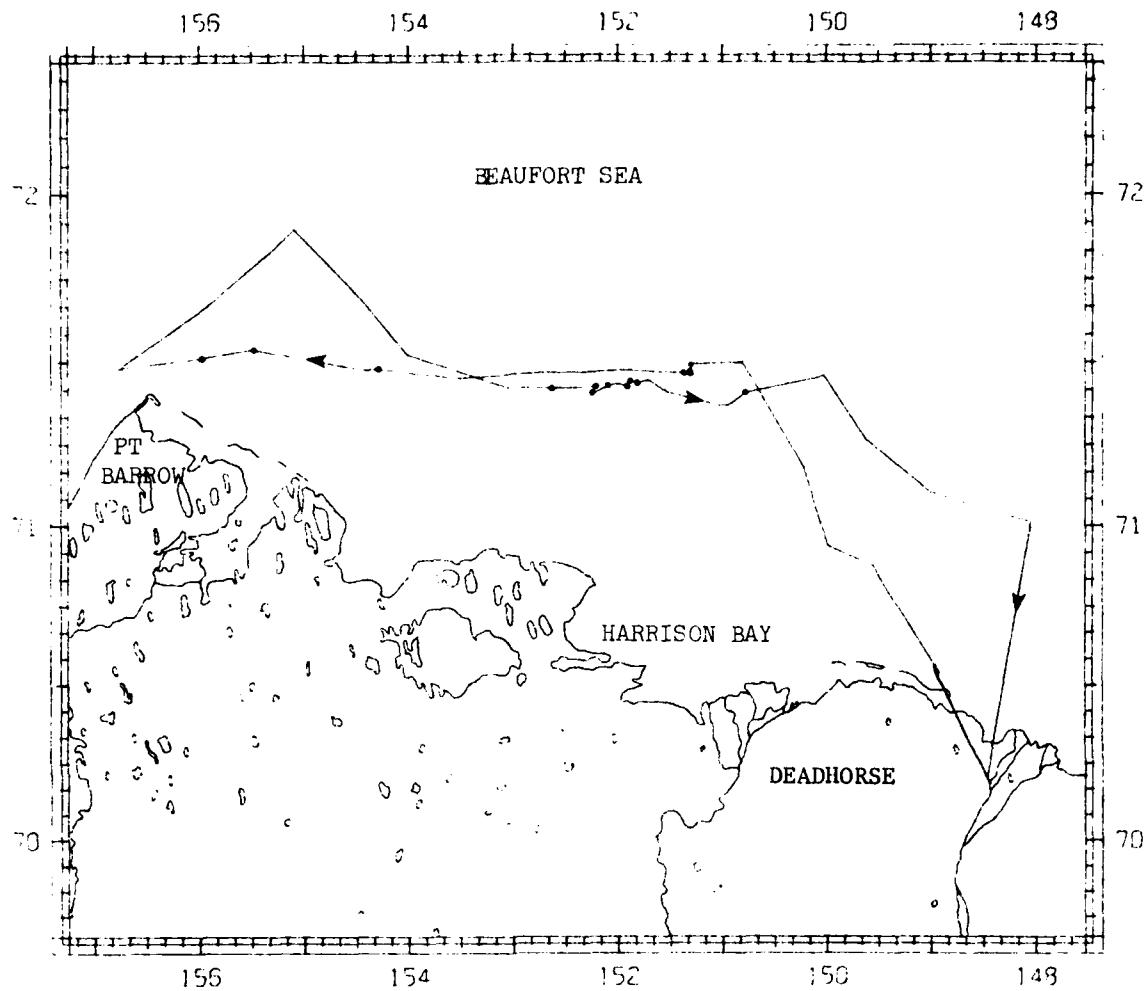


FLIGHT 22. 29 May 1980. Flight was from Deadhorse through Harrison Bay, to Pt. Barrow, and then east. Sighted 57 bowheads heading 050° magnetic. Some were brownish with white or gray coloration on heads. One cow-calf pair was sighted. Recorded unusual sounds in presence of bowheads and unidentified whales. Also sighted 276 belugas and 7 ring seals.

Bowhead Whale Sightings for Flight 23, 30 May 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	151-17.3	71-29.5	60	NE-060	
1	151-18.4	71-28.1	60		
2	151-18.4	71-27.9	60		
1	151-22.1	71-28.0	60	NE-040	Dove under ice
1	154-16.9	71-28.7	60		Dove under ice from small lead
2	155-28.4	71-32.2	60	NE-060	One dove
1	155-57.9	71-30.6	60	NE-040	Swimming at surface
1	152-37.5	71-25.1	60		Resting in small hole
1	152-17.2	71-25.5	60	NE-030	Dove then resurfaced, mottled tan and brown
1	152-14.1	71-24.2	60		On surface in small lead
2	152-05.5	71-25.7	60		Both had white coloration on heads, dove
1	151-54.6	71-25.5	60		In small hole
1	151-57.8	71-26.4	60		Brown, dove
1	151-48.9	71-26.1	60		Dove
3	150-46.7	71-24.3	60		Near ice, close together, not moving

TOTAL 20

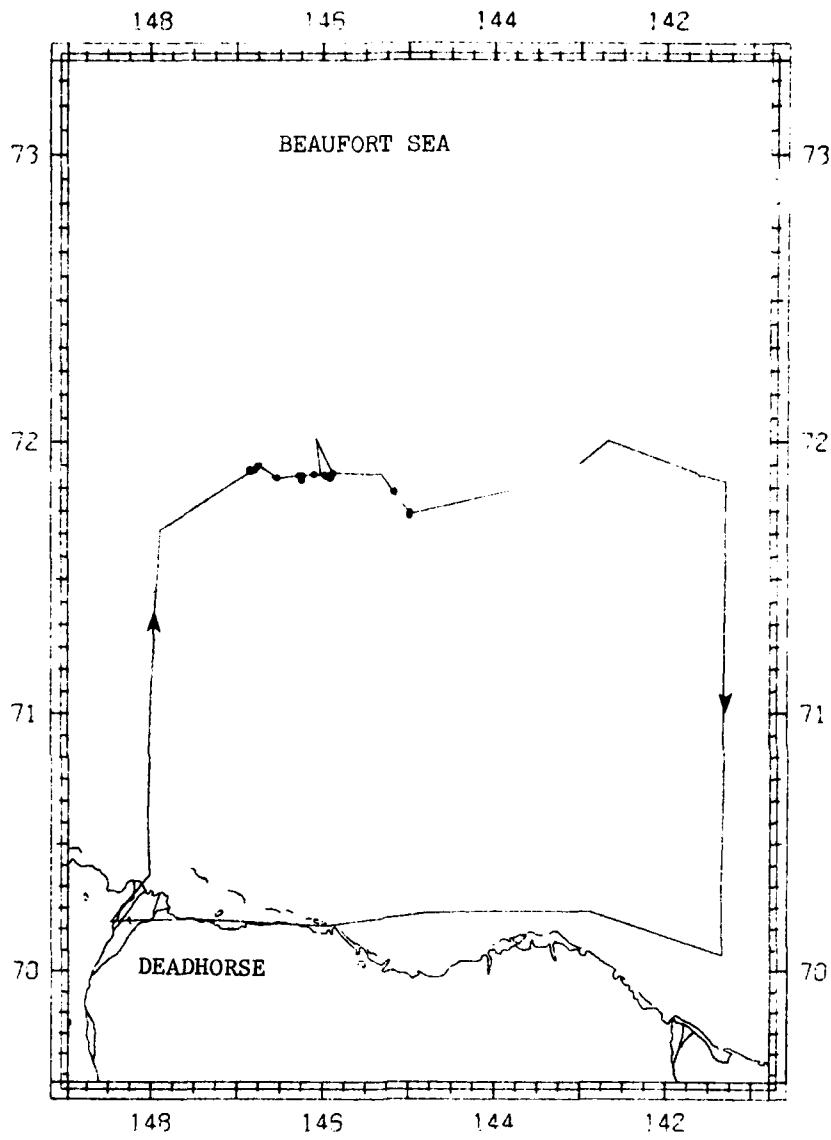


FLIGHT 23. 30 May 1980. Flew from Deadhorse west to Pt. Barrow and returned east along latitude $71^{\circ}30' W$. The lease area was solid ice, so we flew north 20 miles. Here a course parallel to the 10-fathom contour was selected. This area contained small lead systems. Twenty bowheads and approximately 155 belugas were sighted traveling in the direction of between 030° and 045° magnetic. The bowheads and belugas were in separate groups. Two bearded seals and one polar bear were sighted.

Bowhead Whale Sightings for Flight 24, 31 May 1980

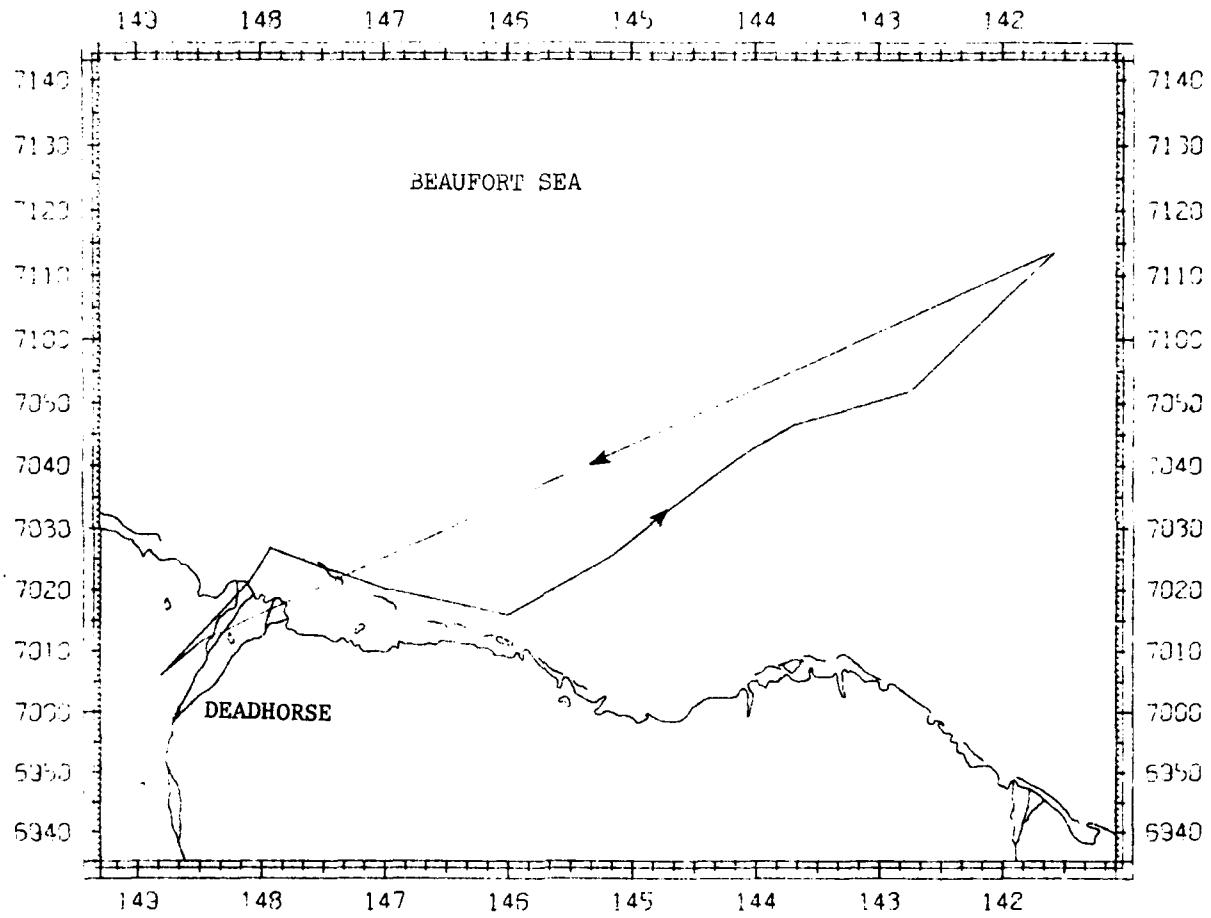
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	146-50.8	71-53.4	120	NE-060	Tan spots on head, dove
1	146-50.1	71-53.8	120	NE-060	Dove under ice
2	146-50.3	71-54.0	120	NE-060	One following the other, white mark on tail of one
3	146-47.1	71-53.9	90	NE-045	White triangle on tail of one
1	146-44.8	71-54.8	90	NE-060	White flippers, lying still
1	146-31.9	71-57.2	90	NE-060	Near ice edge
5	146-16.4	71-57.8	120	NE-050	Moving as a group
1	146-14.9	71-51.7	90	NE-060	
1	146-14.0	71-52.7	120	NE-045	Surface swimming
4	146-06.0	71-53.0	120	NE-050	Surface swimming in group
1	145-58.2	71-57.6	120		Lying still on surface
4	145-54.4	71-52.7	120	NE-060	Close group, swimming nearing ice on surface
2	145-52.4	71-53.2	120	NE-060	Surface swimming
1	145-54.7	71-57.2	120	NE-050	
1	145-09.8	71-49.1	120	NE-050	On surface
1	144-29.1	71-44.3	120	NE-060	

TOTAL 30



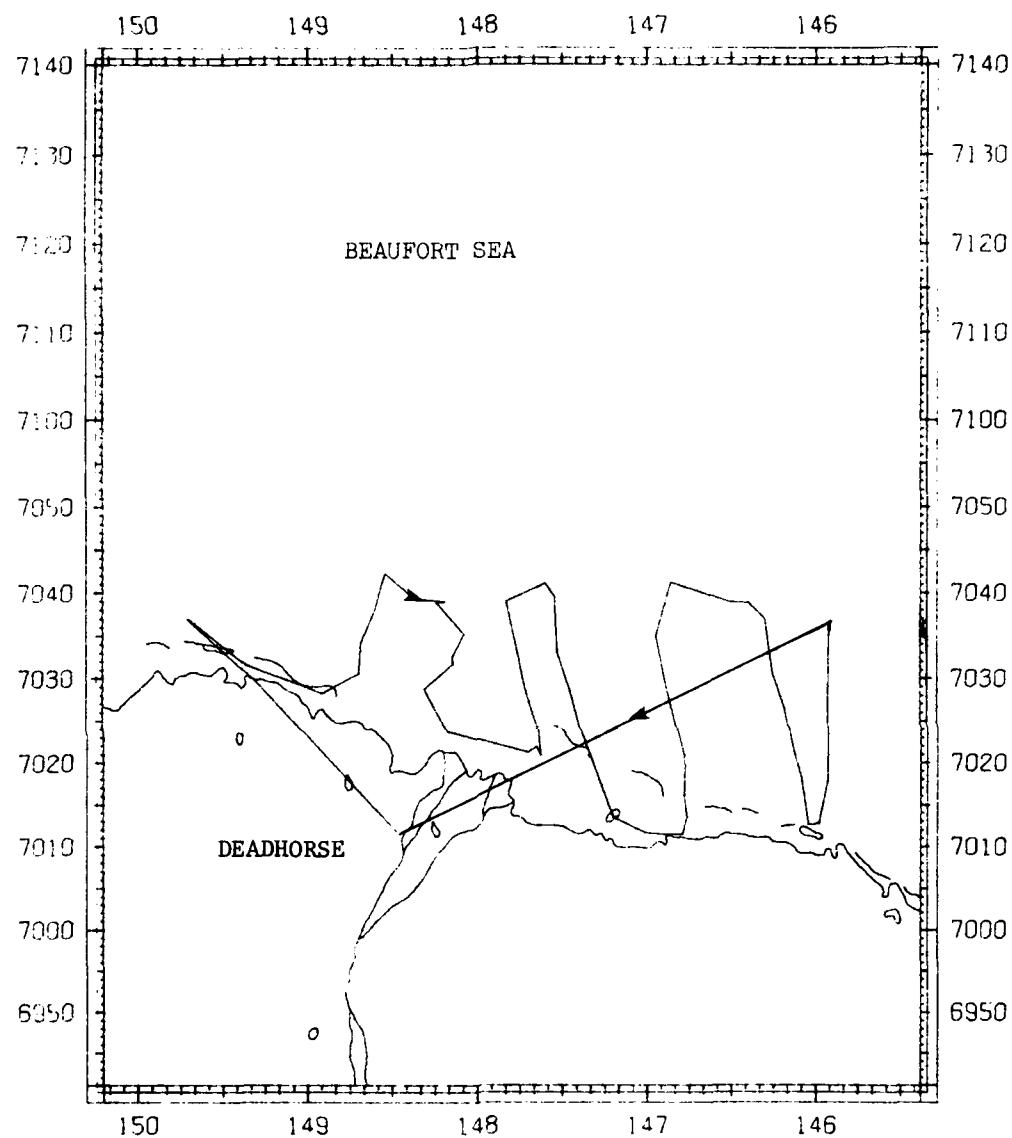
FLIGHT 24. 31 May 1980. Flight to area of $71^{\circ}30' N$, $148^{\circ}00' W$. Thirty bowheads were sighted after following small polynayas in a 045° magnetic direction. Two groups of bowheads, one of 5 and the other of 4, were moving at the surface with belugas. In addition to the bowheads, 8 bearded seals and 113 belugas were sighted. Sonobuoys were dropped and recordings were made.

No bowhead sightings for flight 25, 2 June 1980



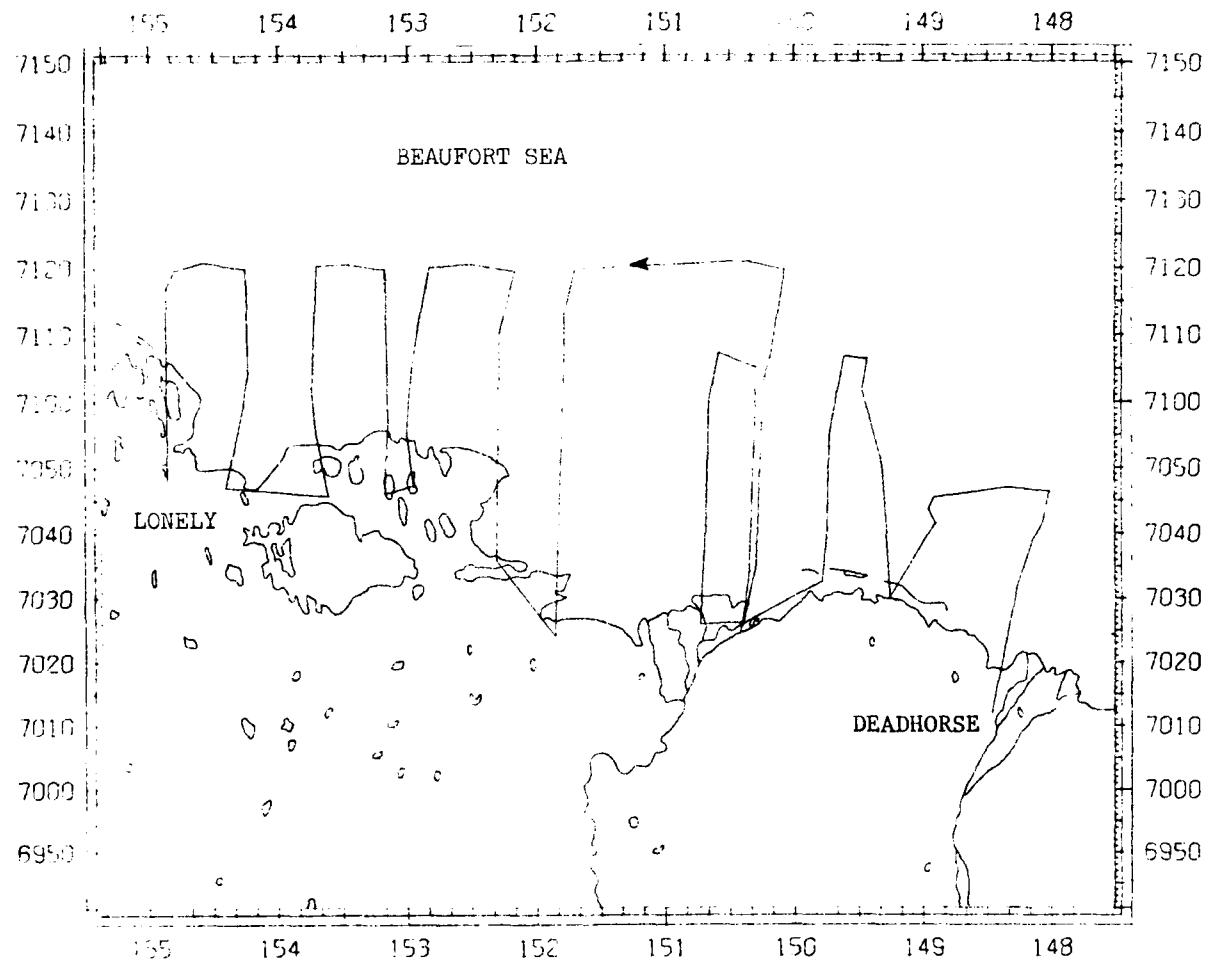
FLIGHT 25. 2 June 1980. This flight was aborted. During this short flight, 13 bearded seals and 1 ring seal were sighted.

No bowhead sightings for flight 26, 2 June 1980



FLIGHT 26. 2 June 1980. Flew transects that included Joint State-Federal lease area. This portion of the lease area was icebound, with the exception of broken ice patches and some isolated leads. Sighted 95 ring seals, 1 bearded seal, and 1 polar bear.

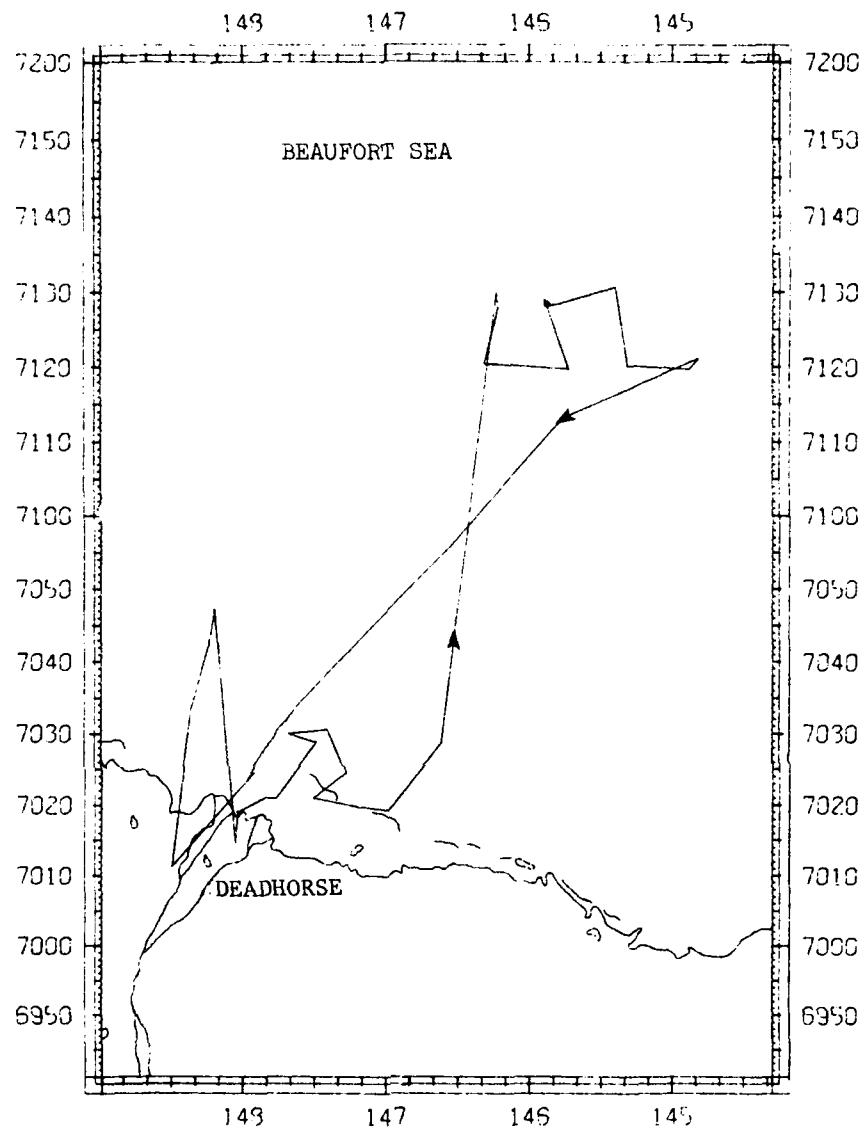
No bowhead sightings for flight 27, 3 June 1980



FLIGHT 27. 3 June 1980. Flight included the Joint State-Federal and Federal lease areas. The lease area to Cape Simpson was mostly icebound with isolated leads and fractures. Sighted 2 bearded seals and 16 ring seals.

Bowhead Whale Sightings for Flight 28, 5 June 1980

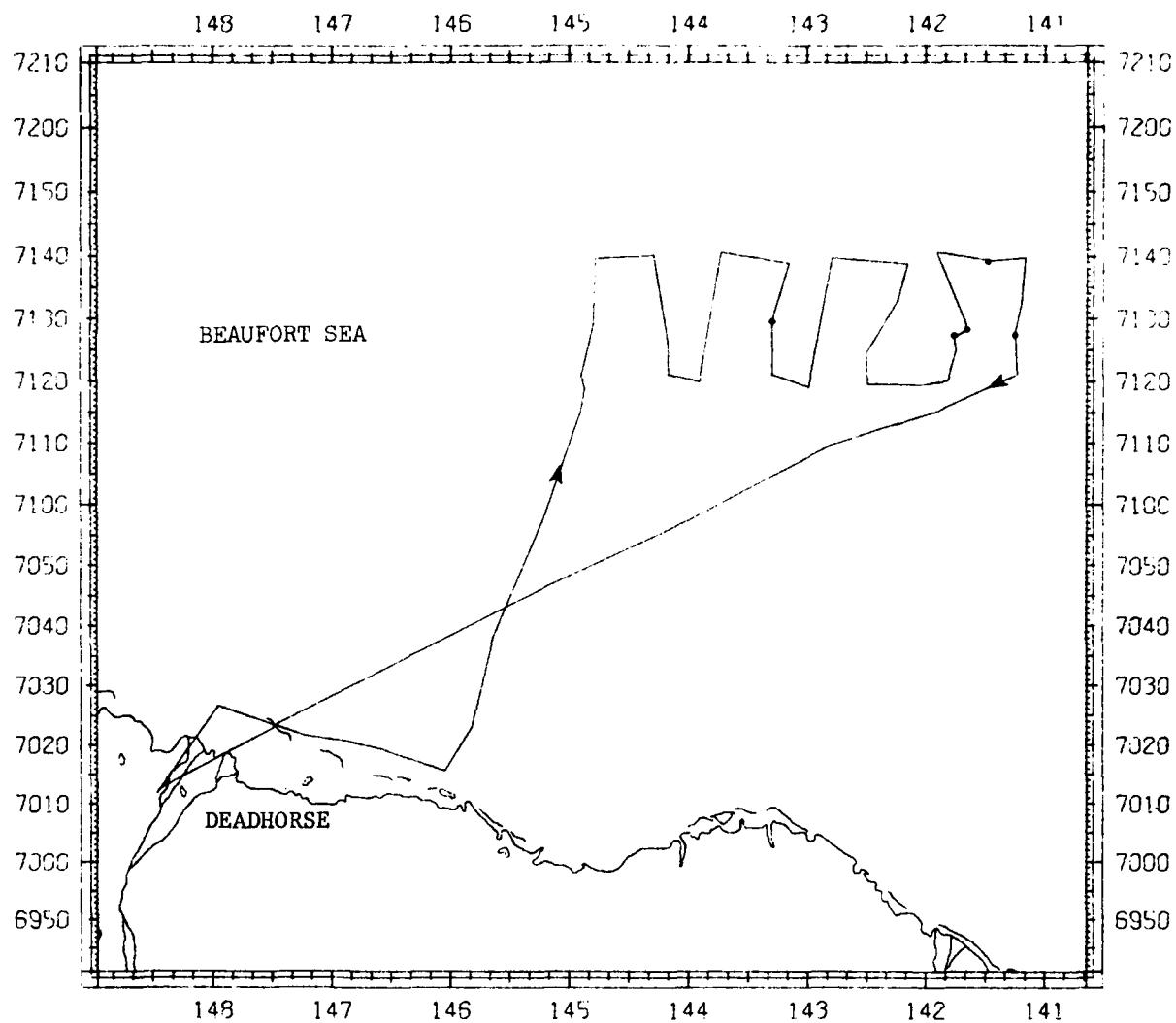
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	145-52.5	71-28.4	180		White coloration on head
TOTAL 1					



FLIGHT 28. 5 June 1980. This flight included the area between $71^{\circ}20'$ N and $71^{\circ}40'$ N. Flight transects were east from $71^{\circ}20'$ N, $148^{\circ}00'$ W to $71^{\circ}30'$ N, $144^{\circ}51'$ W. Ice coverage was all greater than 9/10 with scattered small leads and holes. Sighted 59 ring seals, 31 belugas and 1 bowhead. Sonobuoys were dropped, but no marine mammal sounds were recorded.

Bowhead Whale Sightings for Flight 29, 6 June 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	143-17.6	71-29.6	150	NE-060	Dove in response to aircraft
1	141-45.6	71-27.3	150	NE-060	Dove, 12 meters long
1	141-39.0	71-28.2			Tan fluke, dove
1	141-28.8	71-39.0		NE-060	Some tan markings, dove
1	141-15.0	71-27.5			At end of narrow lead
TOTAL 5					

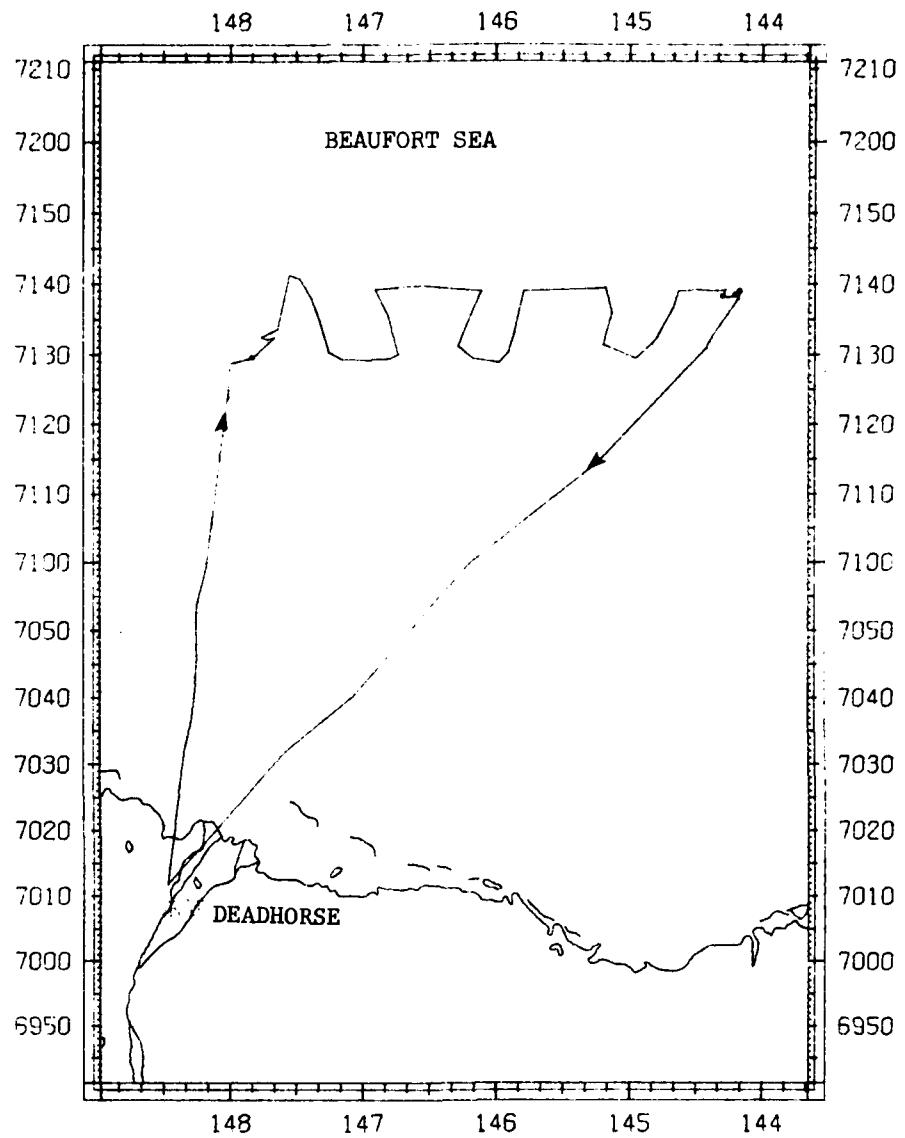


FLIGHT 29. 6 June 1980. Flight north and east centered on latitude $71^{\circ}30'$ N. The first leg of the flight was from Deadhorse through the center of the eastern part of the Joint State-Federal lease area. The ice coverage was greater than 9/10 with some small leads. Sighted 5 bowheads. One had some tan markings, the others were basically black. All dove immediately as we passed over them. Their general heading was 060° magnetic. Also sighted 2 bearded seals, 26 ring seals, and 15 belugas.

Bowhead Whale Sightings for Flight 30, 7 June 1980

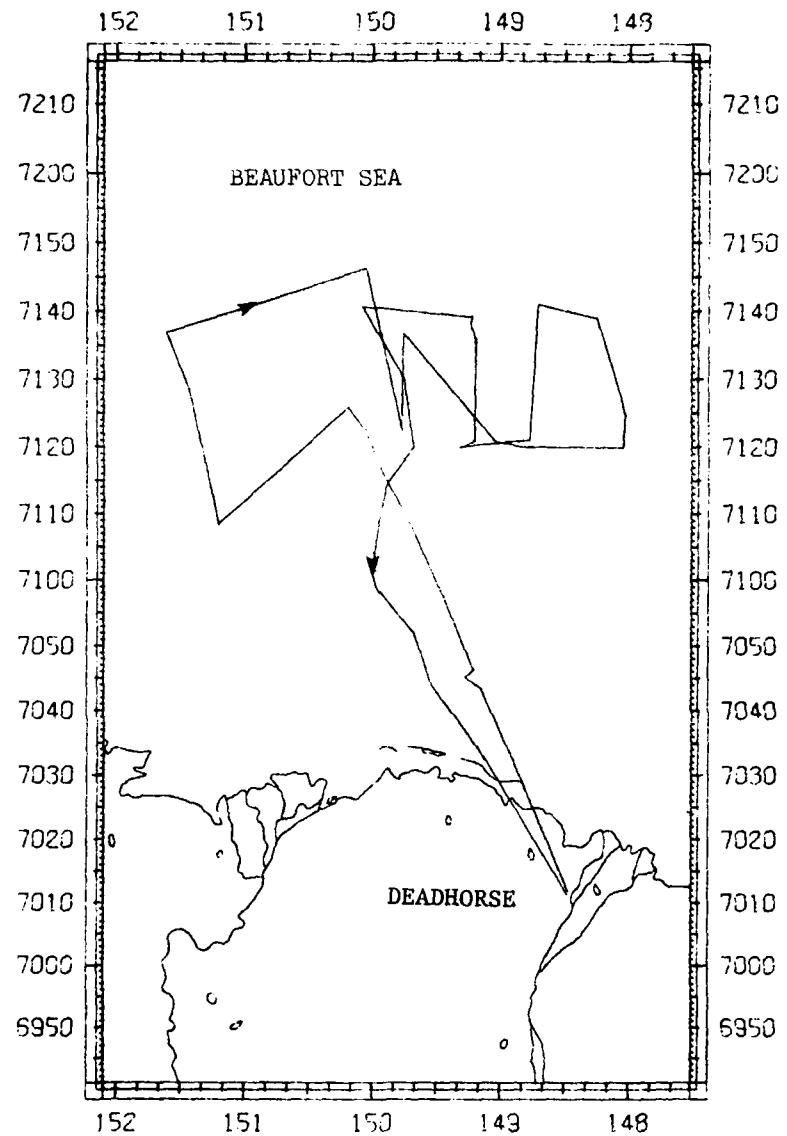
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	147-40.0	71-32.4	150		Dove, in small polynya
1	144-17.3	71-38.3	150	NE-060	White fluke, dove, in small lead
1	144-11.8	71-38.5			Blew
2	144-10.0	71-39.0			One with white coloration on head, dove

TOTAL 5



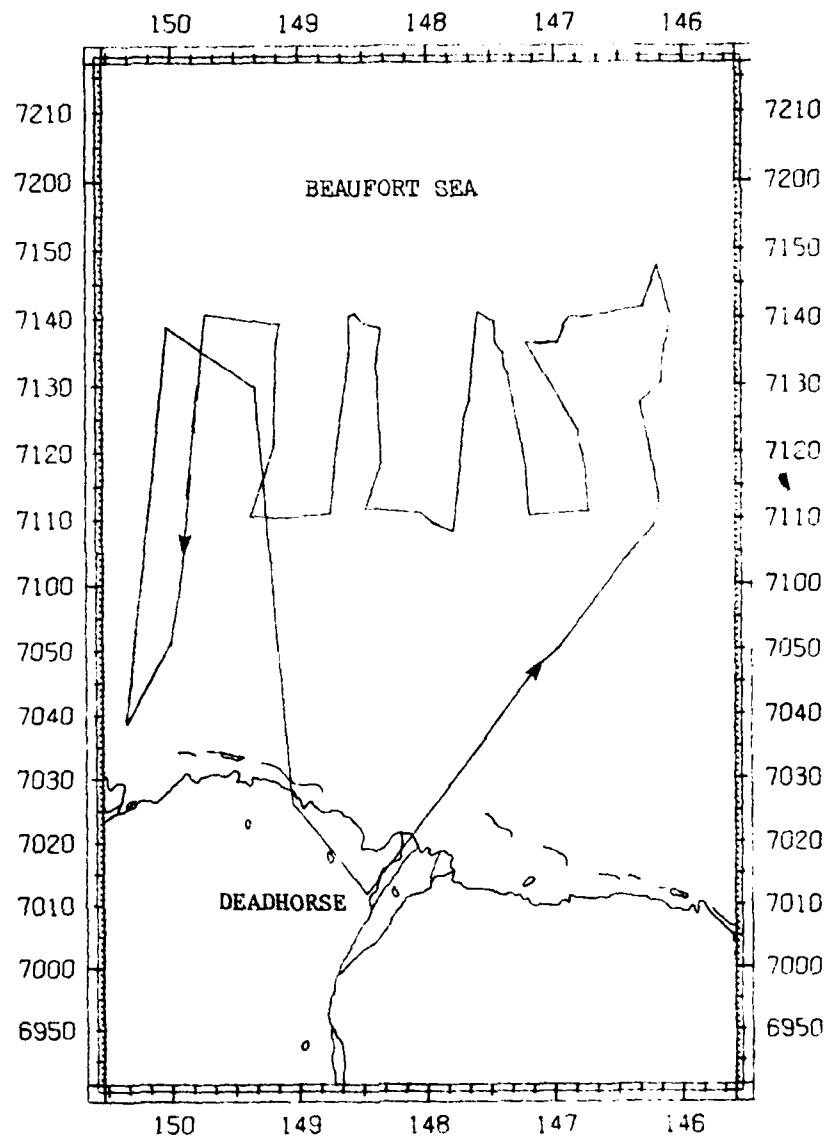
FLIGHT 30. 7 June 1980. This flight was north of the Joint State-Federal oil lease area. The ice coverage was estimated at 7/10, with many leads. Five bowheads were sighted, one with white coloration on the head, another with white markings on the fluke. A sonobuoy was dropped and sounds recorded. Also sighted 40 belugas, and 171 ring seals.

No bowhead sightings for flight 31, 10 June 1980



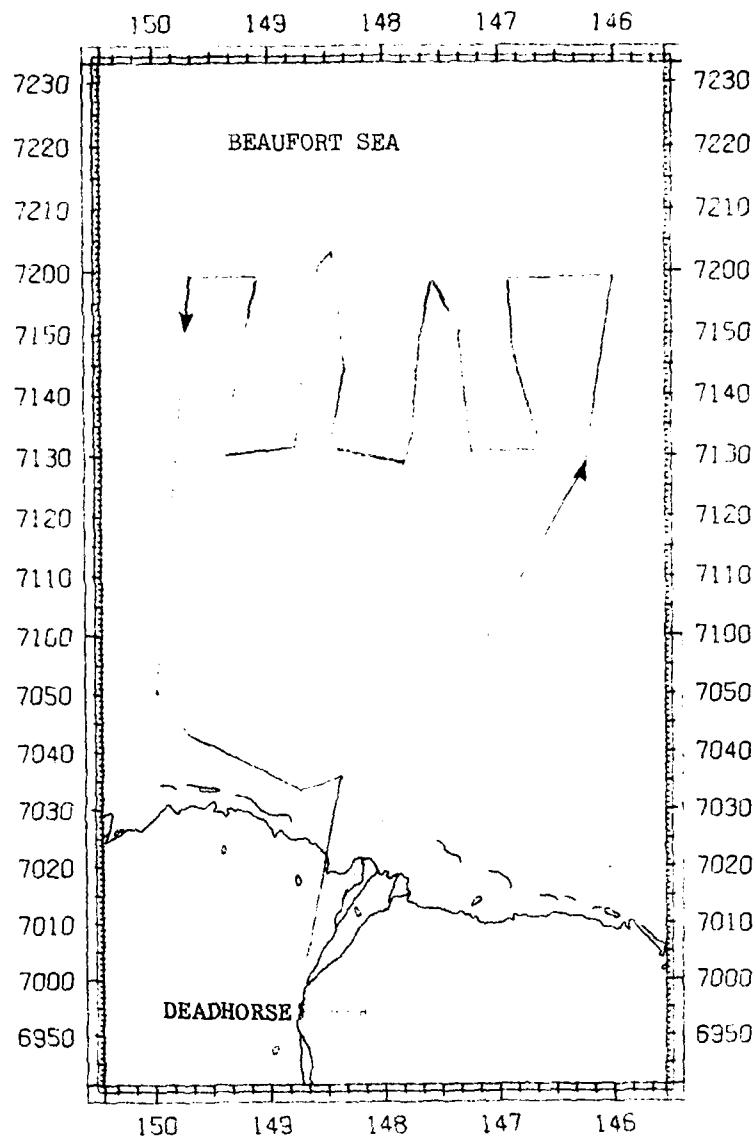
FLIGHT 31. 10 June 1980. Flight was to the area of the suspected migratory route. No bowheads were seen. Six belugas, 45 ring seals, and 1 polar bear were sighted.

No bowhead sightings for flight 32, 11 June 1980



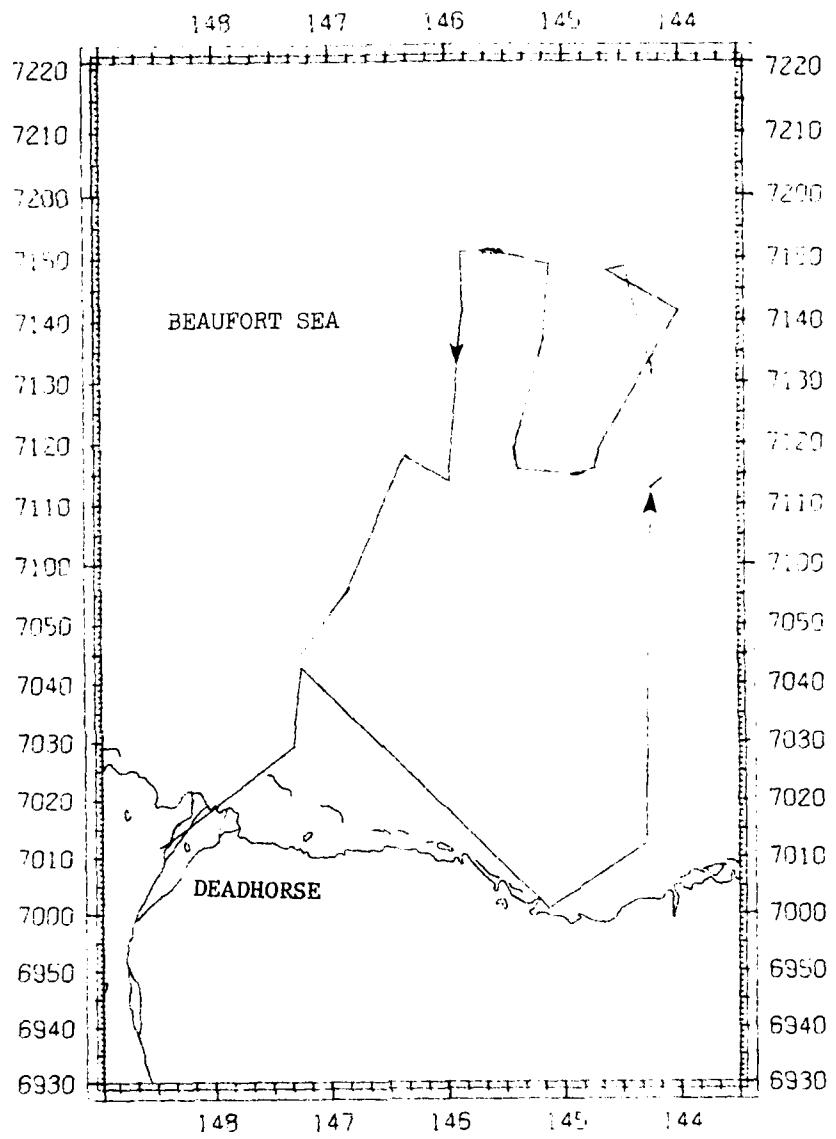
FLIGHT 32. 11 June 1980. Flight was north of Joint State-Federal lease area. The ice coverage was greater than 9/10 with fractures and small leads. Sighted 141 ring seals and 66 belugas.

No bowhead sightings for flight 33, 13 June 1980



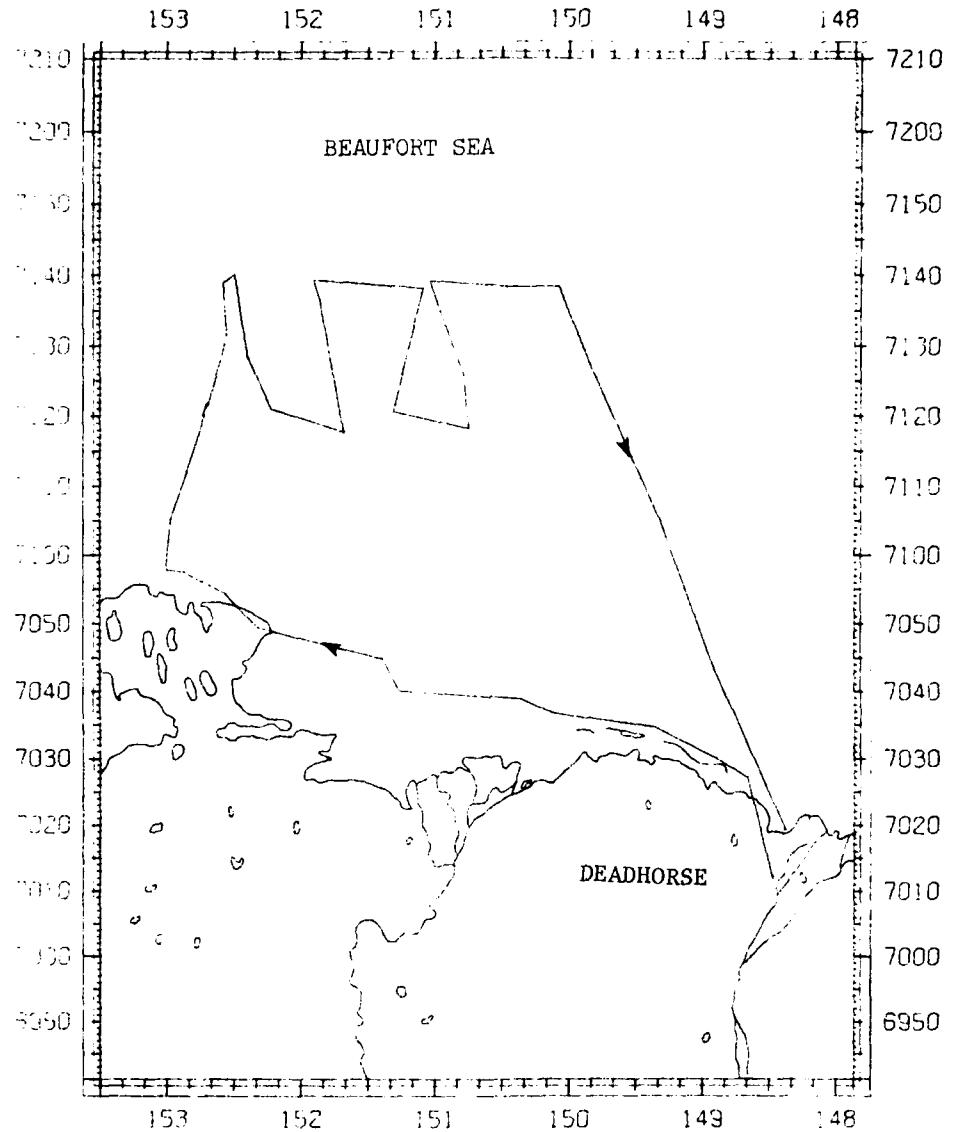
FLIGHT 33. 13 June 1980. Flight was north of the Joint State-Federal lease area. Ice coverage was greater than 9/10. Sighted 98 ring seals.

No bowhead sightings for flight 34, 16 June 1980



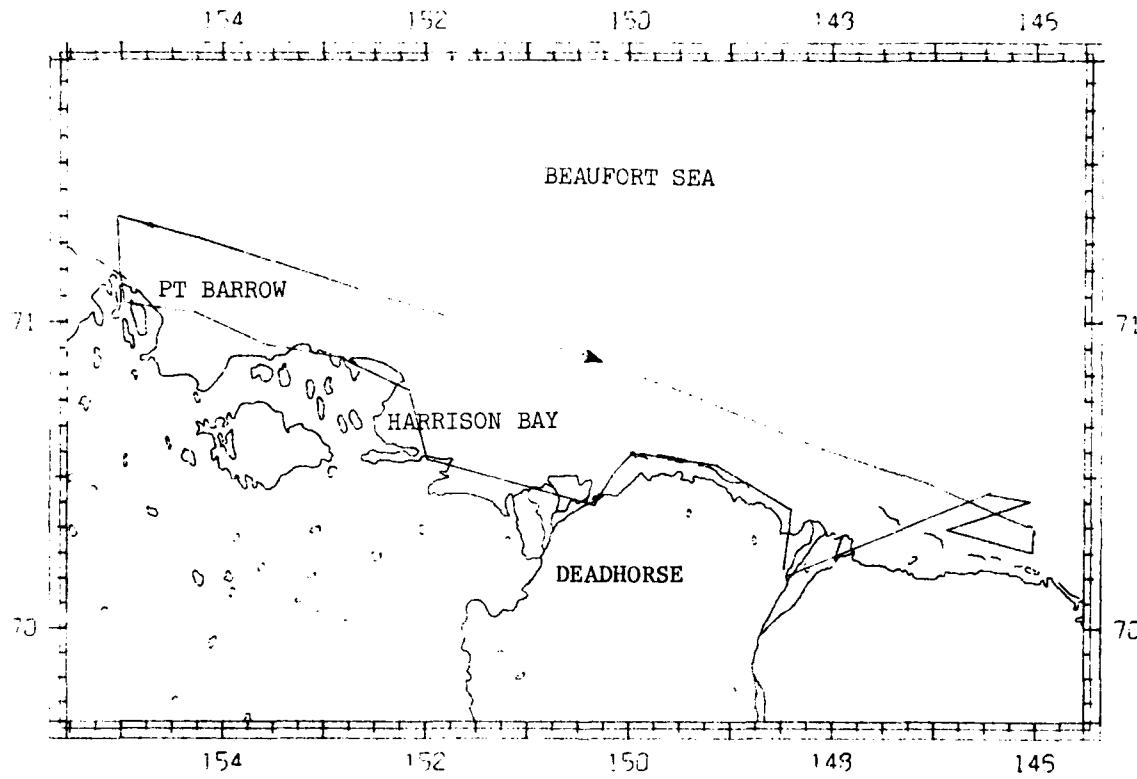
FLIGHT 34. 16 June 1980. Flight was north and east of the Joint State-Federal lease area. The ice coverage was greater than 9/10, with some fractures and minor leads. Fifteen ring seals were sighted.

No bowhead sightings for flight 35, 19 June 1980



FLIGHT 35. 19 June 1980. Flight included the Federal lease area and north. Fog restricted visibility. The ice coverage was greater than 9/10 with many refrozen fractures and leads. Seven ring seals were sighted.

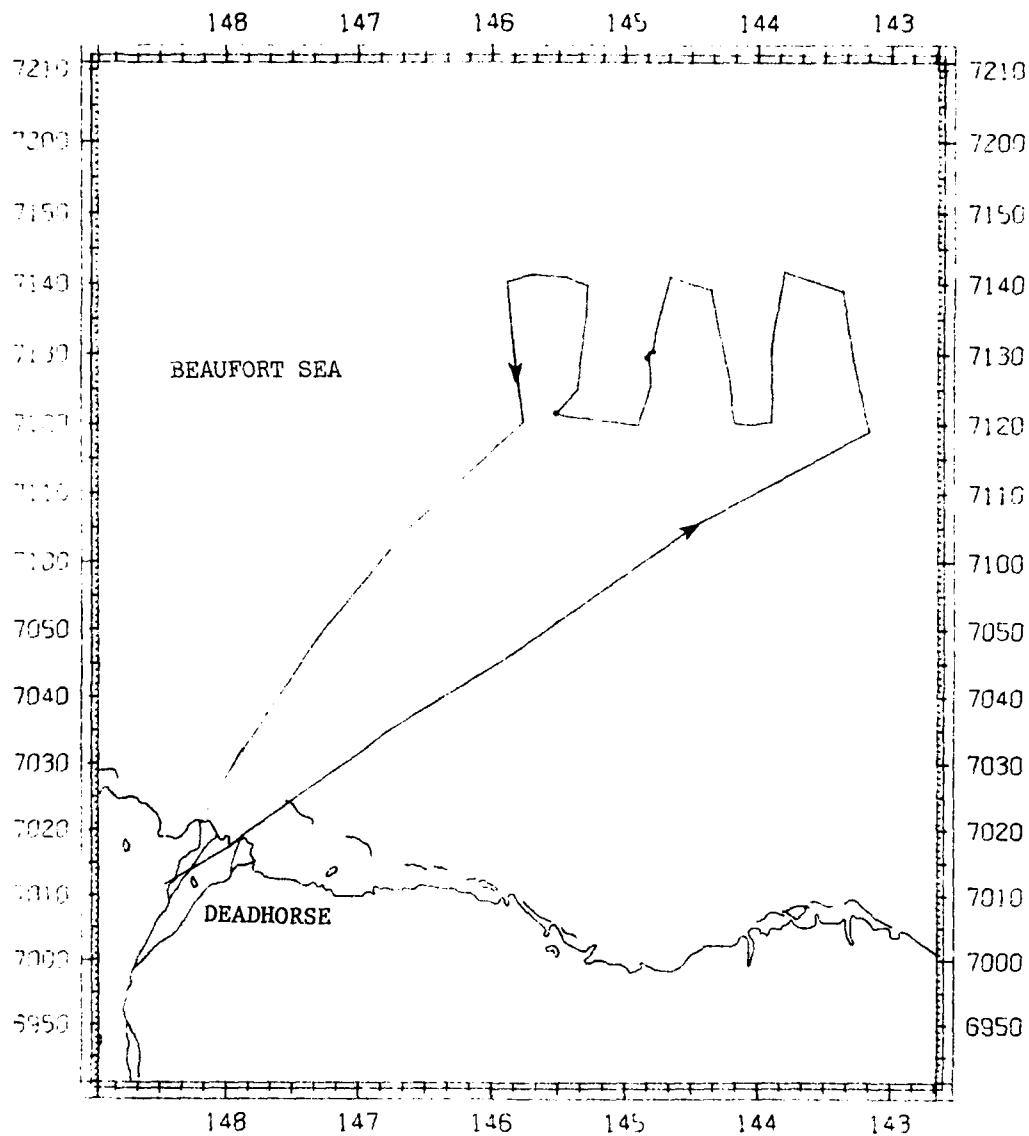
No bowhead sightings for flight 36, 21 June 1980



FLIGHT 36. 21 June 1980. This flight included the perimeters of the Federal and Joint State-Federal lease areas. The lease areas were icebound. Inside the Barrier Islands river runoff was evident. Four ring seals were sighted.

Bowhead Whale Sightings for Flight 37, 23 June 1980

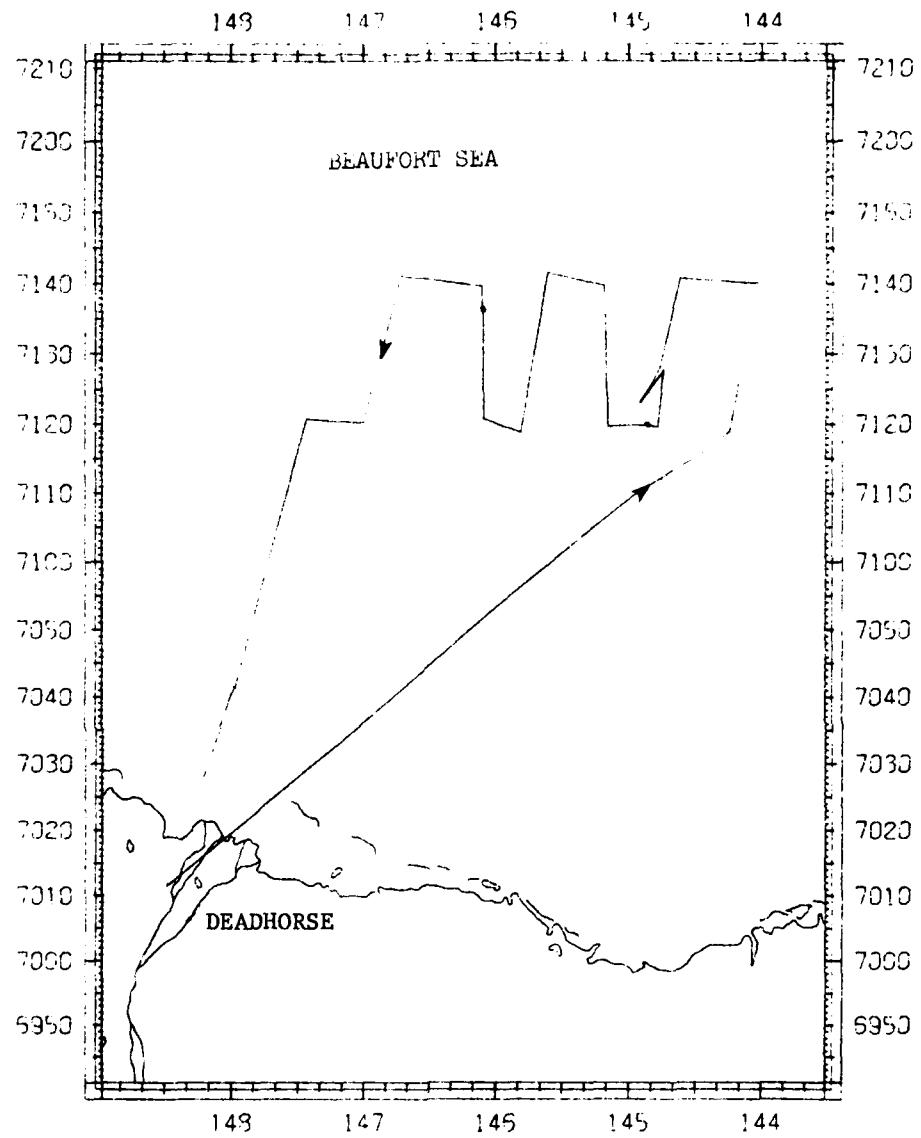
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	144-47.5	71-30.4	150		Breached in hole
1	144-50.0	71-29.5		NE-060	Blew and dove
1	145-31.2	71-21.6	15	NE-050	Dove
TOTAL 3					



FLIGHT 37. 23 June 1980. Flight was north of the Joint State-Federal lease area. Ice coverage was greater than 7/10 with many small fractures and leads. Three bowheads were sighted.

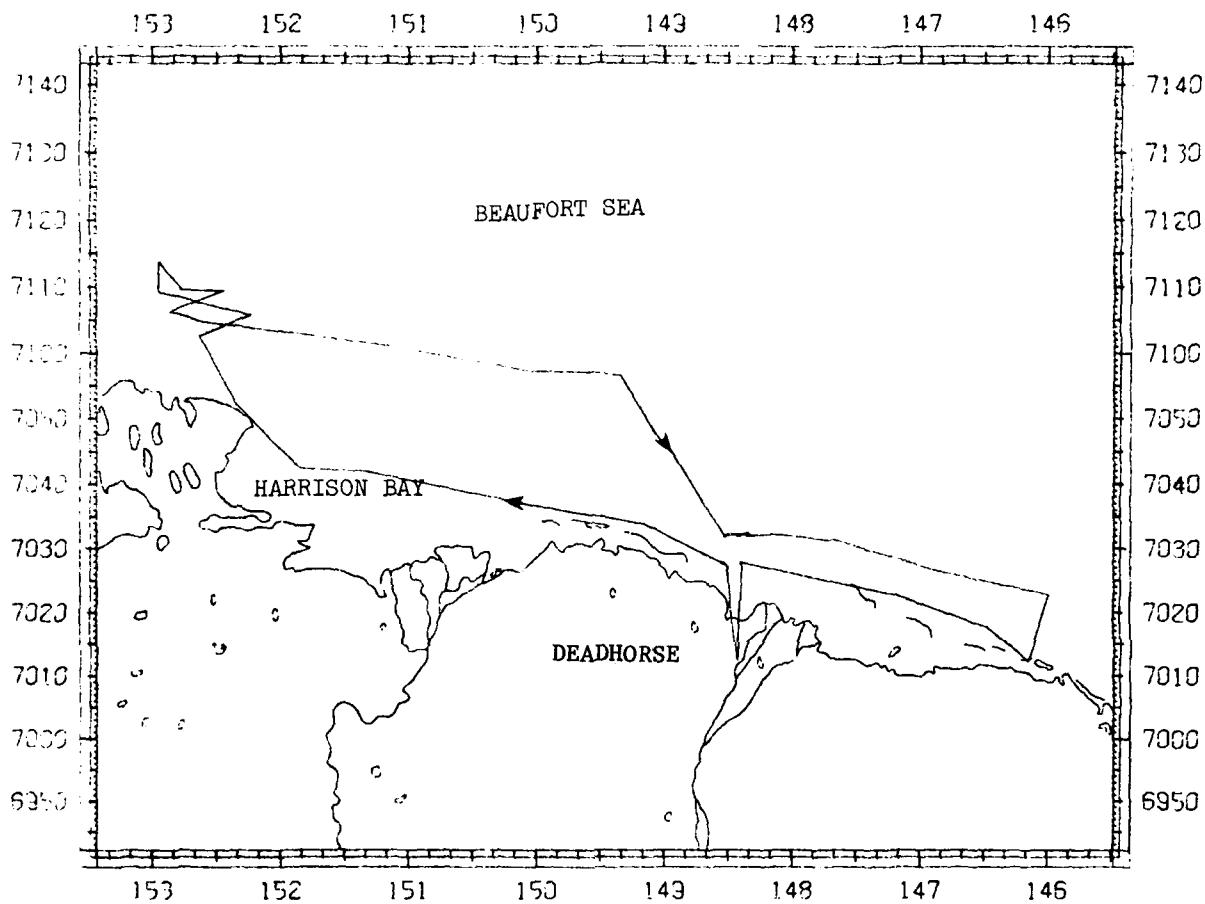
Bowhead Whale Sightings for Flight 38, 27 June 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Heading (Magnetic)	Behavior and Observations
1	144-51.4	71-19.9		NE-045	Dove
1	146-05.5	71-34.4		NE-360	Brown head, white tail stock, dove
TOTAL 2					



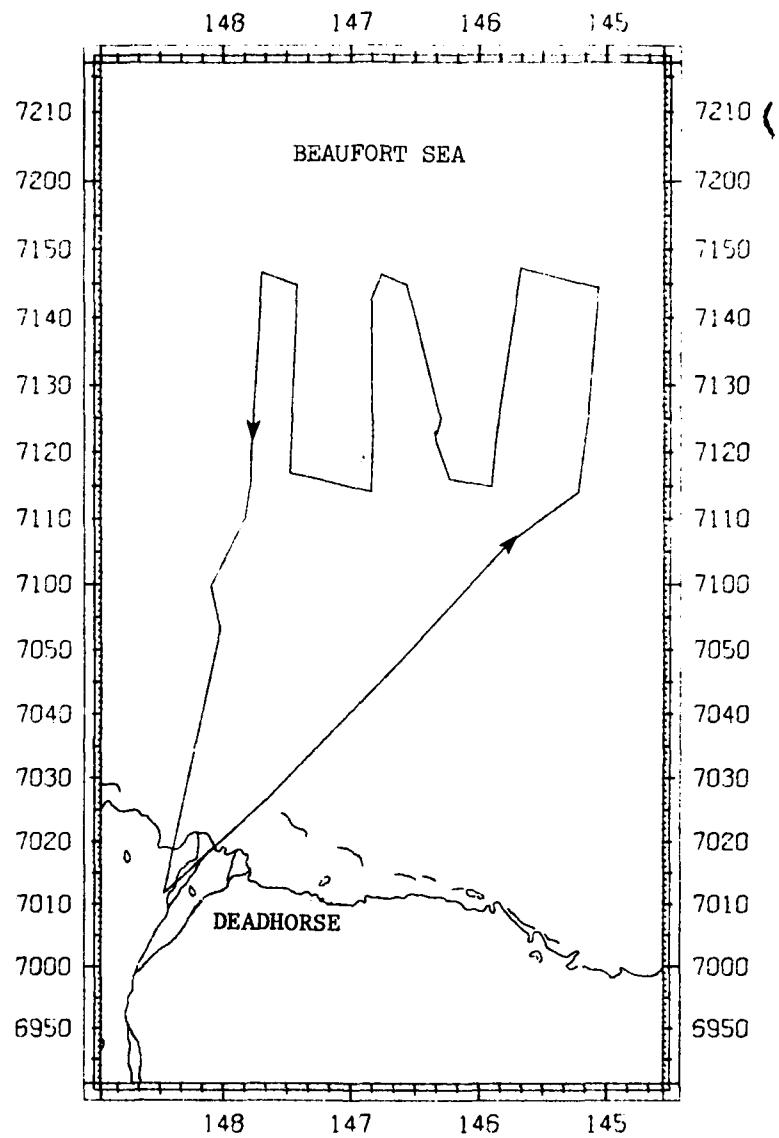
FLIGHT 38. 27 June 1980. Flight was north of the Joint State-Federal lease area. Ice coverage was greater than 7/10 with many holes and extensive small leads. Two bowheads were sighted. One had a brown head and white markings on the tail stock. This whale was heading 360° magnetic. Also sighted 33 belugas and 3 ring seals.

No bowhead sightings for flight 39, 1 July 1980



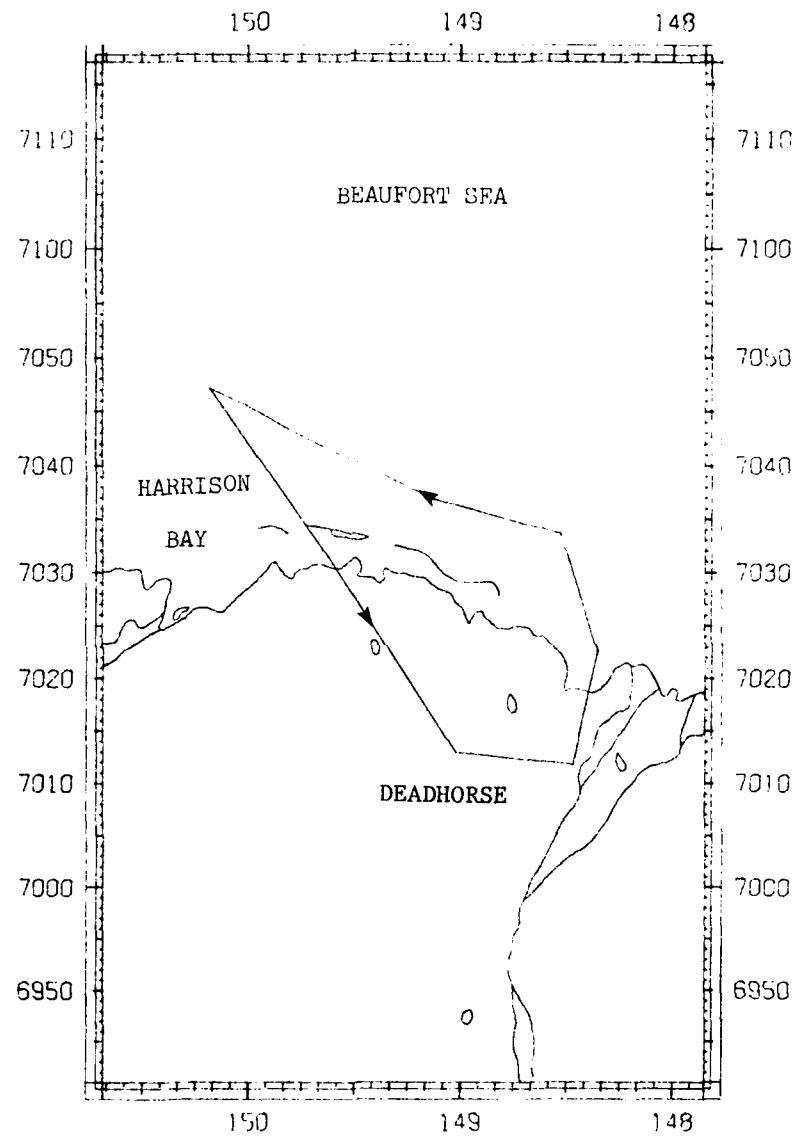
FLIGHT 39. 1 July 1980. Flight included the perimeters of the Federal and Joint State-Federal lease areas. The area inside the Barrier Islands and within the influence of the rivers was ice free, with occasional grease ice. This ice-free area extended from 1.1 to 5.1 km offshore. The ice outside this area was estimated at 7/10 and had some holes and well defined small leads. No marine mammals were sighted during this flight.

No bowhead sightings for flight 40, 5 July 1980



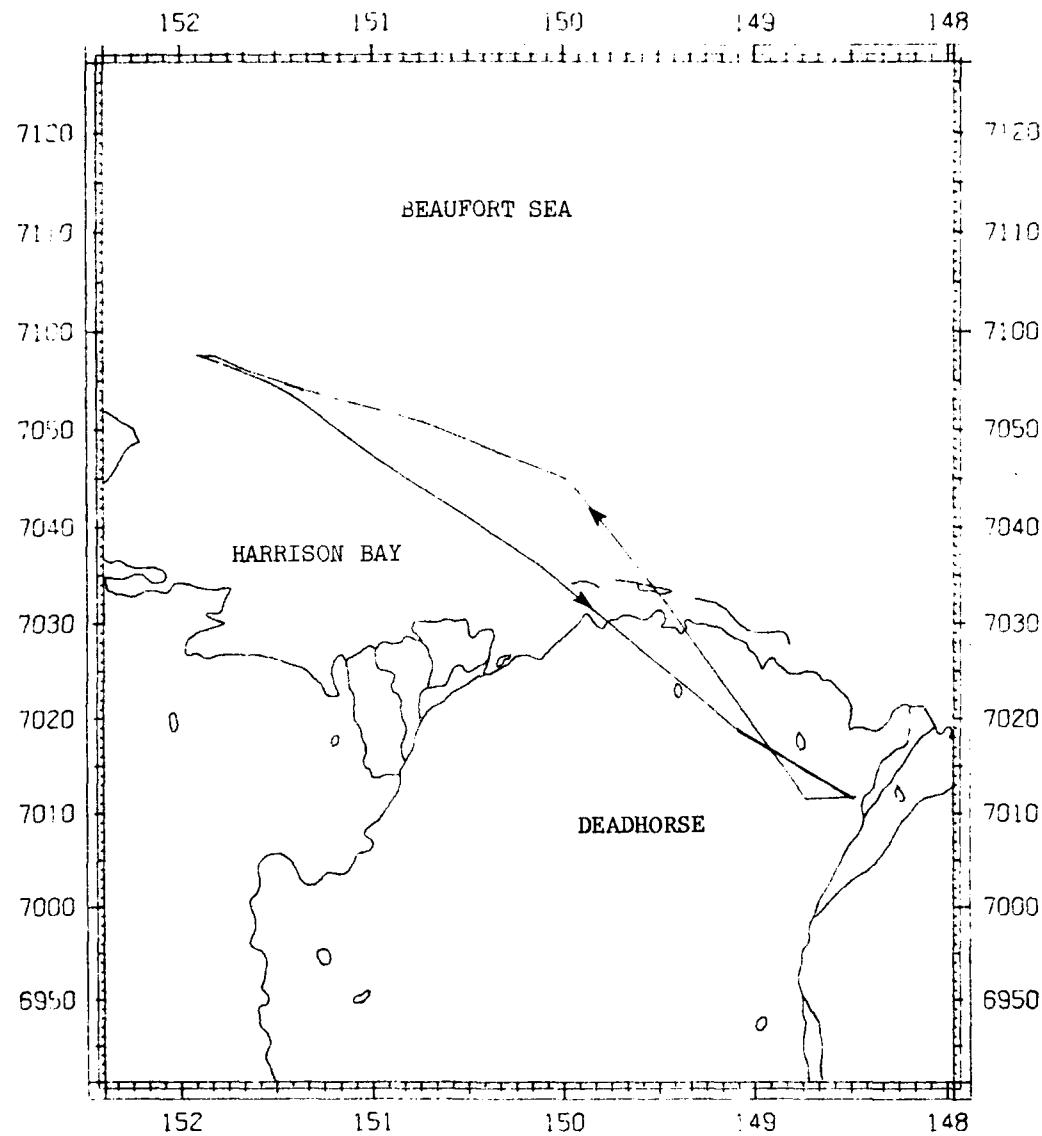
FLIGHT 40. 5 July 1980. Flight was north of the Joint State-Federal lease area. Ice coverage varied from 7/10 to 9/10 with many holes and small leads. Eight ring seals and 1 polar bear were sighted.

No bowhead sightings for flight 41, 9 July 1980



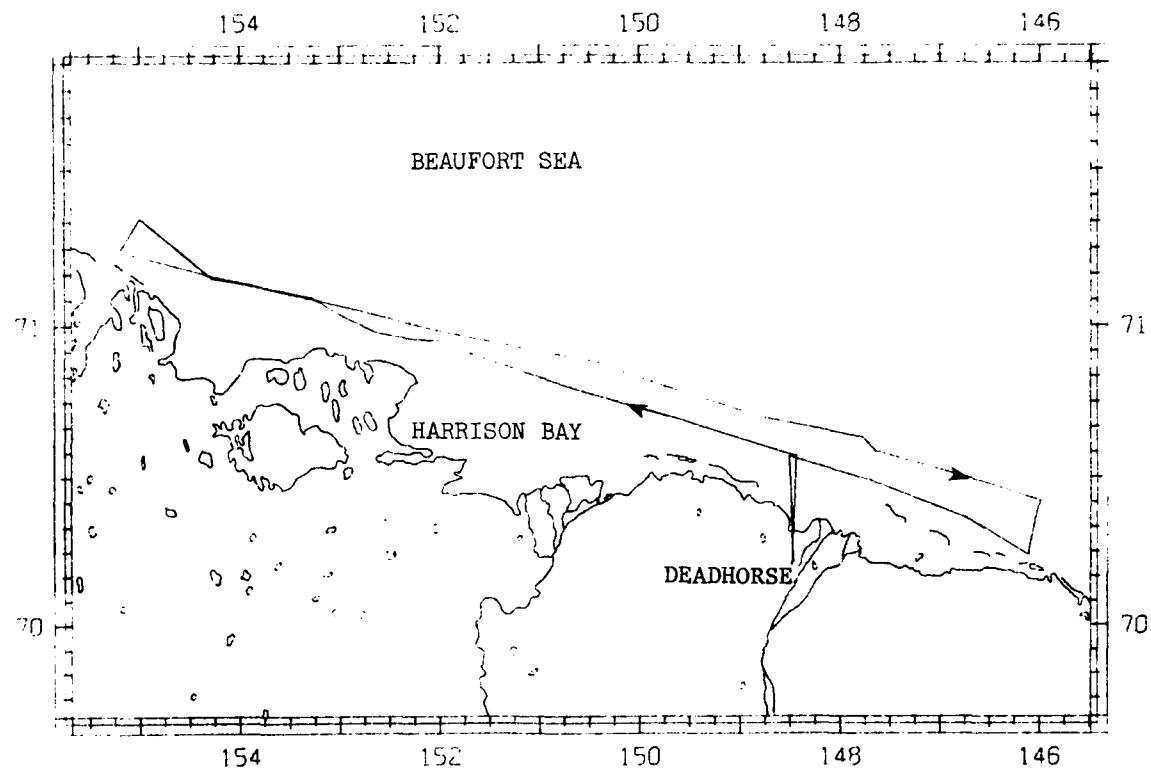
FLIGHT 41. 9 July 1980. The flight was terminated after an hour because of poor visibility due to fog.

No bowhead sightings for flight 42, 10 July 1980



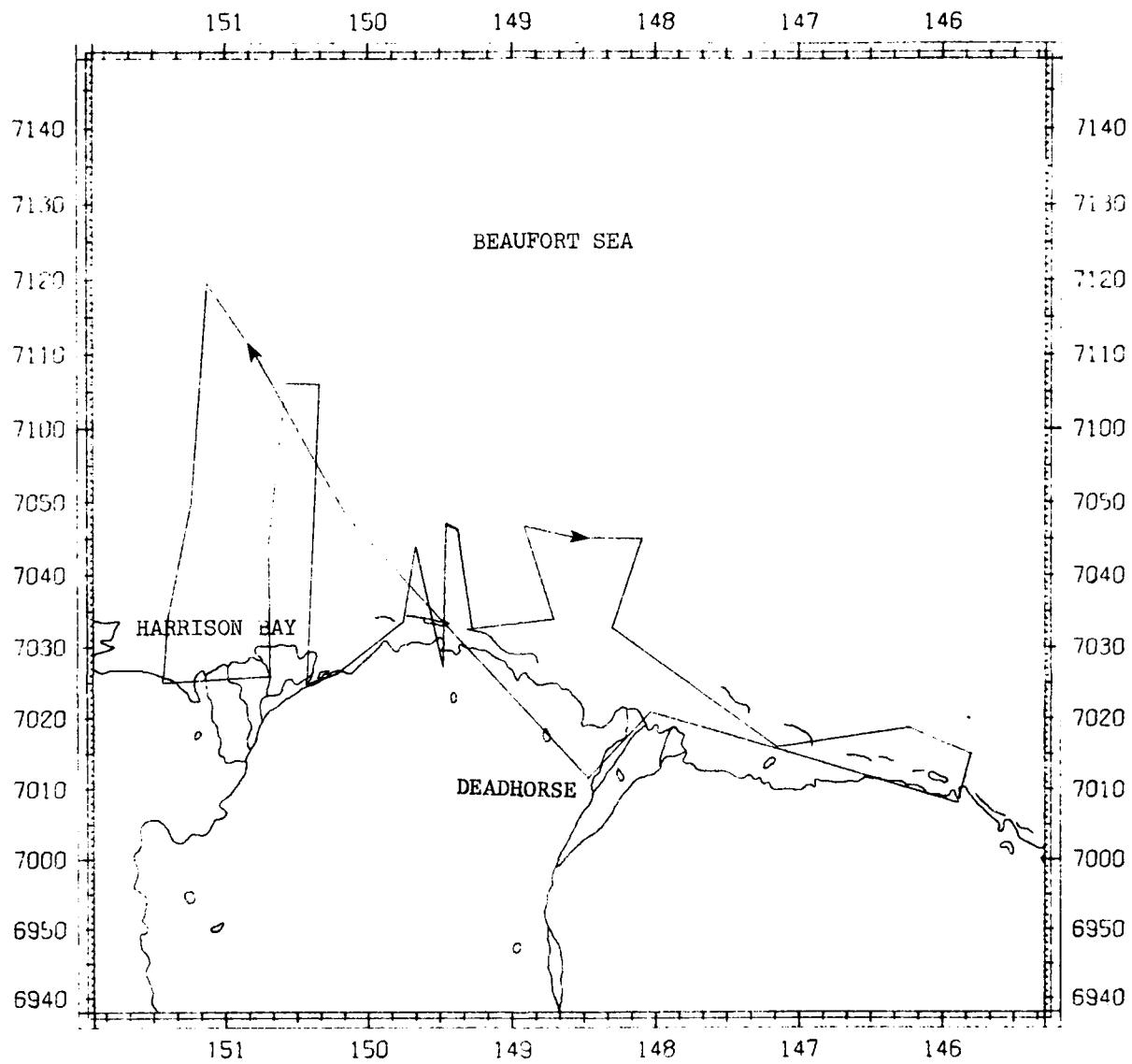
FLIGHT 42. 10 July 1980. Flight was terminated due to fog. Two bearded seals and 39 ring seals were sighted.

No bowhead sightings for flight 43, 14 July 1980



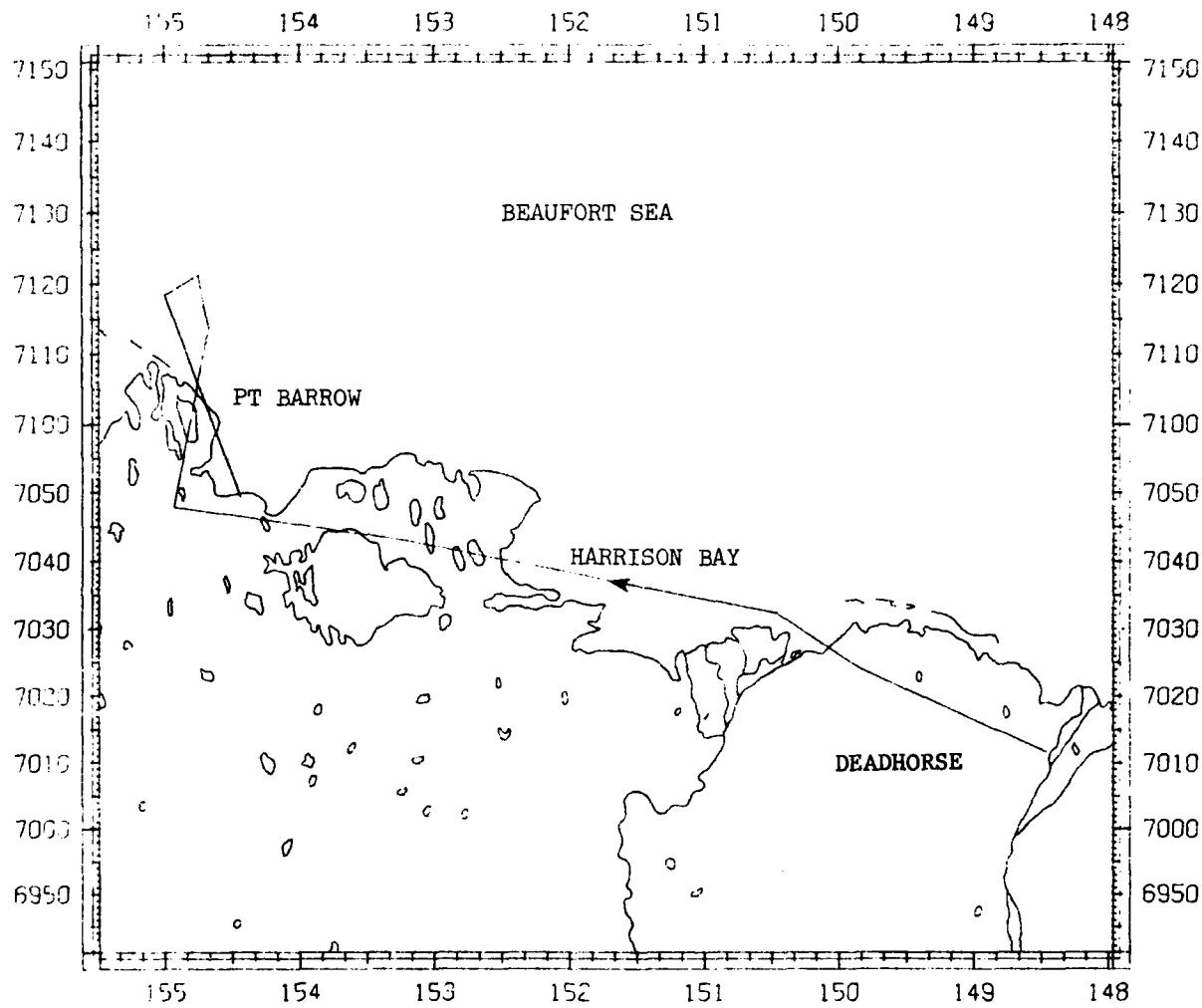
FLIGHT 43. 14 July 1980. Flight was through Federal and Joint State-Federal lease areas. The ice coverage varied from open water with some floes to 7/10 to 9/10 coverage. The ice appeared to be breaking up inside the Barrier Islands. Three ring seals were sighted.

No bowhead sightings for flight 44, 15 July 1980



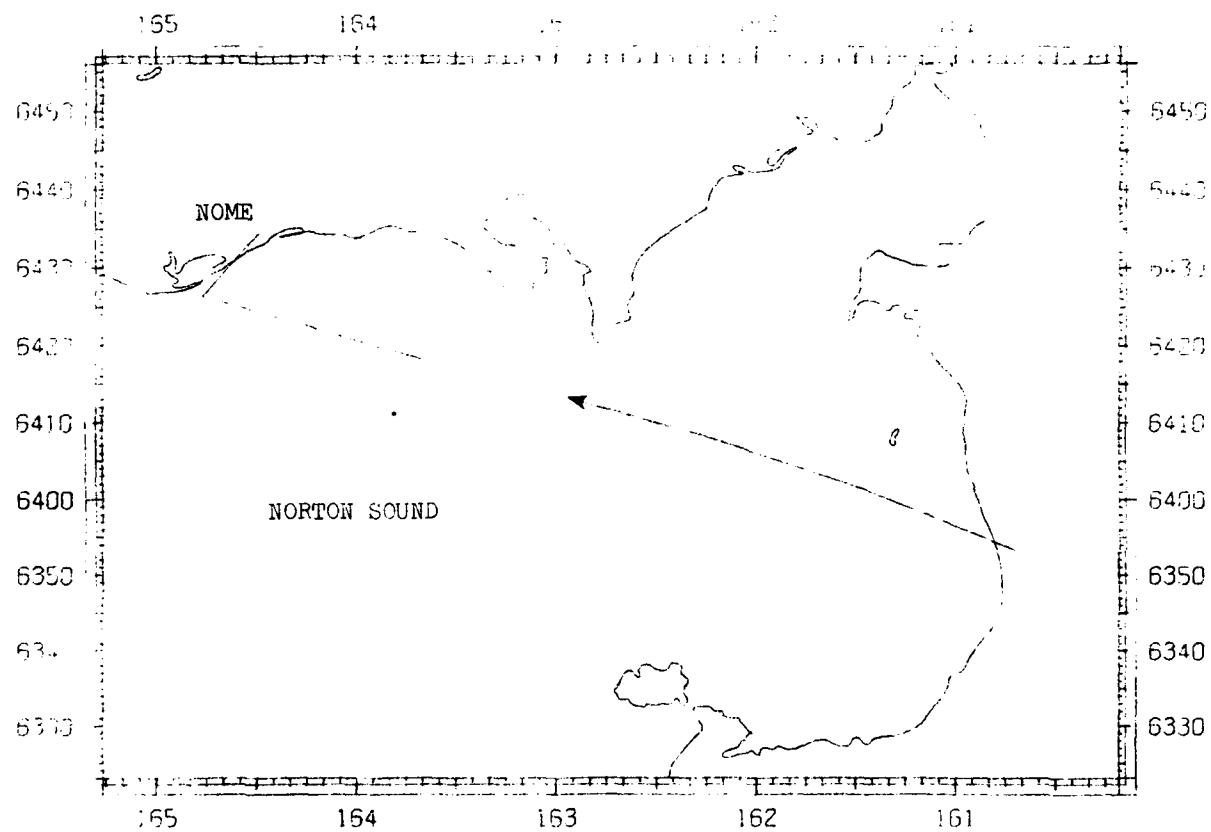
FLIGHT 44. 15 July 1980. Partial transects of Federal and Joint State-Federal lease areas were flown. Ice coverage was variable, from open water to 8/10 and 9/10 coverage. On the ocean side of the Barrier Islands, there was much open water with floes of various sizes present. No marine mammals were sighted.

No bowhead sightings for flight 45, 15 July 1980



FLIGHT 45. 15 July 1980. Flight aborted due to fog.

No bowhead sightings for flight 46, 19 July 1980



FLIGHT 46. 19 July 1980. Flight was from Anchorage to Nome via Norton Sound. There were no sightings in Norton Sound.

No bowhead sightings for flight 47, 20 July 1980

Gray Whale Sightings for Flight 47, 20 July 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
1	166-22.5	68-29.3	300
1	166-22.5	68-29.3	300
1	166-14.1	68-45.5	300
1	166-14.1	68-49.1	300
1	160-44.3	70-22.9	300
1	159-54.6	70-44.6	300
1	159-78.9	70-53.9	520
1	159-11.5	70-55.0	520
1	158-53.1	70-57.6	300
1	156-53.4	71-14.0	450

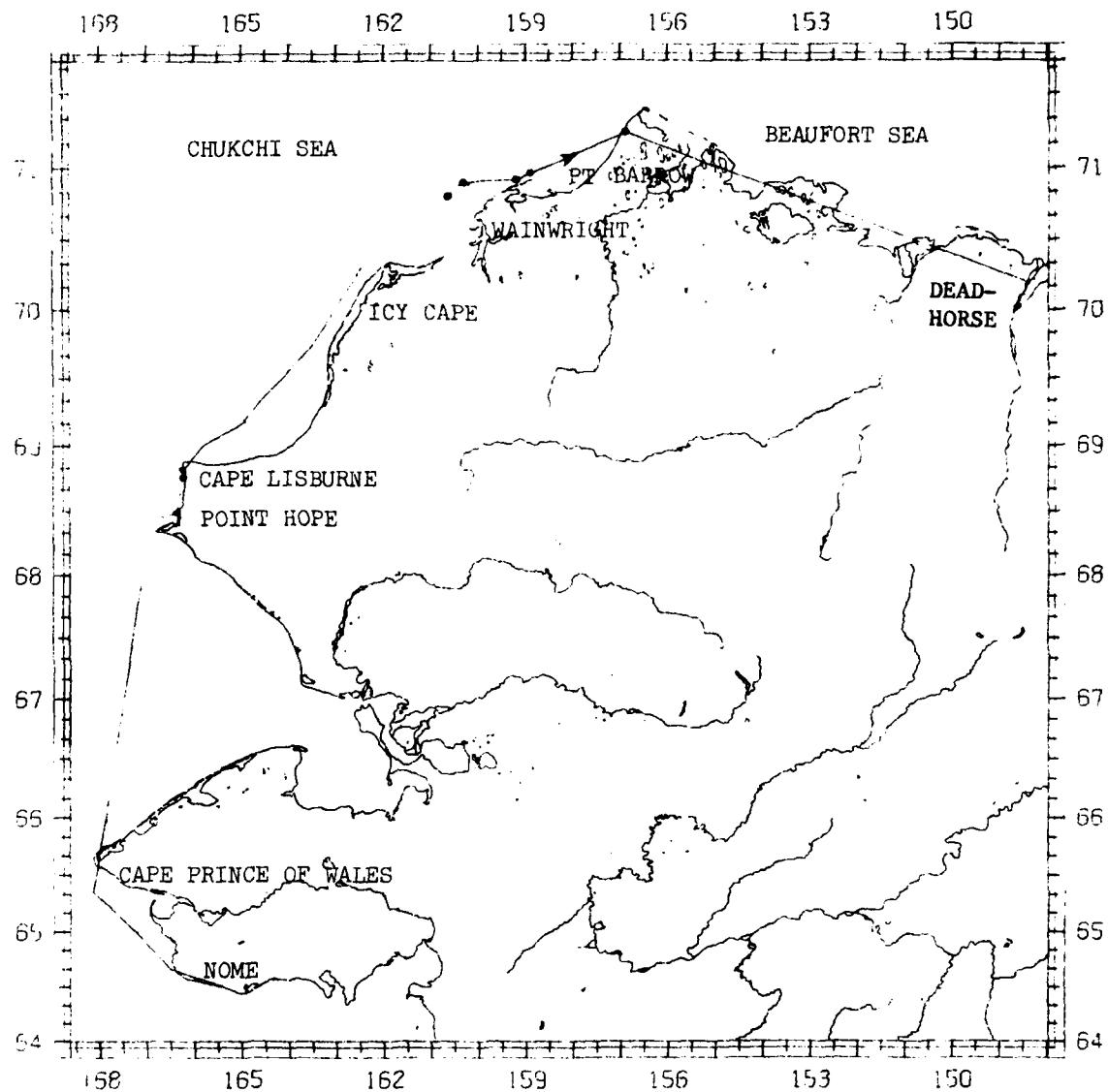
TOTAL 10

FLIGHT 47. 20 July 1980. Description continued:

Gray whales were sighted in three locations: near Point Hope, Cape Lisburne, and Pt. Barrow, with intermediate sightings in between. The gray whales near Point Hope and Cape Lisburne were within 2 km of the beach. Sexual or social behavior, in addition to feeding, was noted. Clouds of mud in the water were estimated to cover an area of at least 3 km. Pods of up to 5 whales with close body contact were seen. There was little response to the circling aircraft. The whales near Pt. Barrow were less than 1 km from the beach and appeared to be feeding in 5/10 ice coverage.

Beluga sightings were made during this coastal flight. The most southerly sighting was near Point Hope. Belugas were sighted near gray whales, in some cases almost touching.

Open water conditions were present until south of Point Hope, where the first small pan ice was noted. Northwest of Cape Lisburne the ice coverage was estimated at 7/10, at which time walrus sightings became common but were not counted.



FLIGHT 47. 20 July 1980. Flight was from Nome to Deadhorse. Coastal surveys from Point Barrow to Deadhorse were not possible due to heavy fog. See facing page for sighting descriptions.

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FLIGHTS 48 through 51 (21 July - 24 July) were in support of whale tagging efforts in the eastern Canadian Beaufort Sea.

No bowhead sightings for flight 52, 25 July 1980

C-100

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NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA
AERIAL SURVEYS OF ENDANGERED WHALES IN THE BEAUFORT SEA, CHUKCHI-ETC(U)
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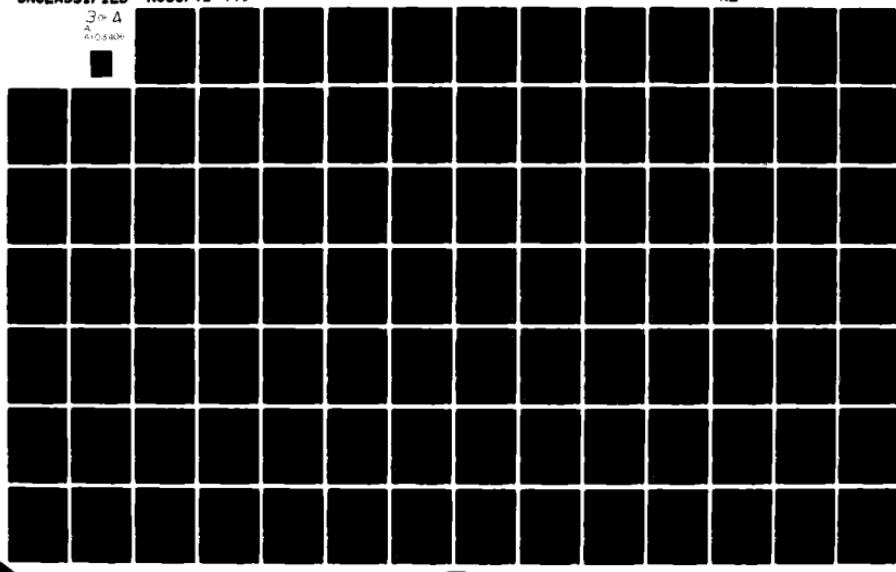
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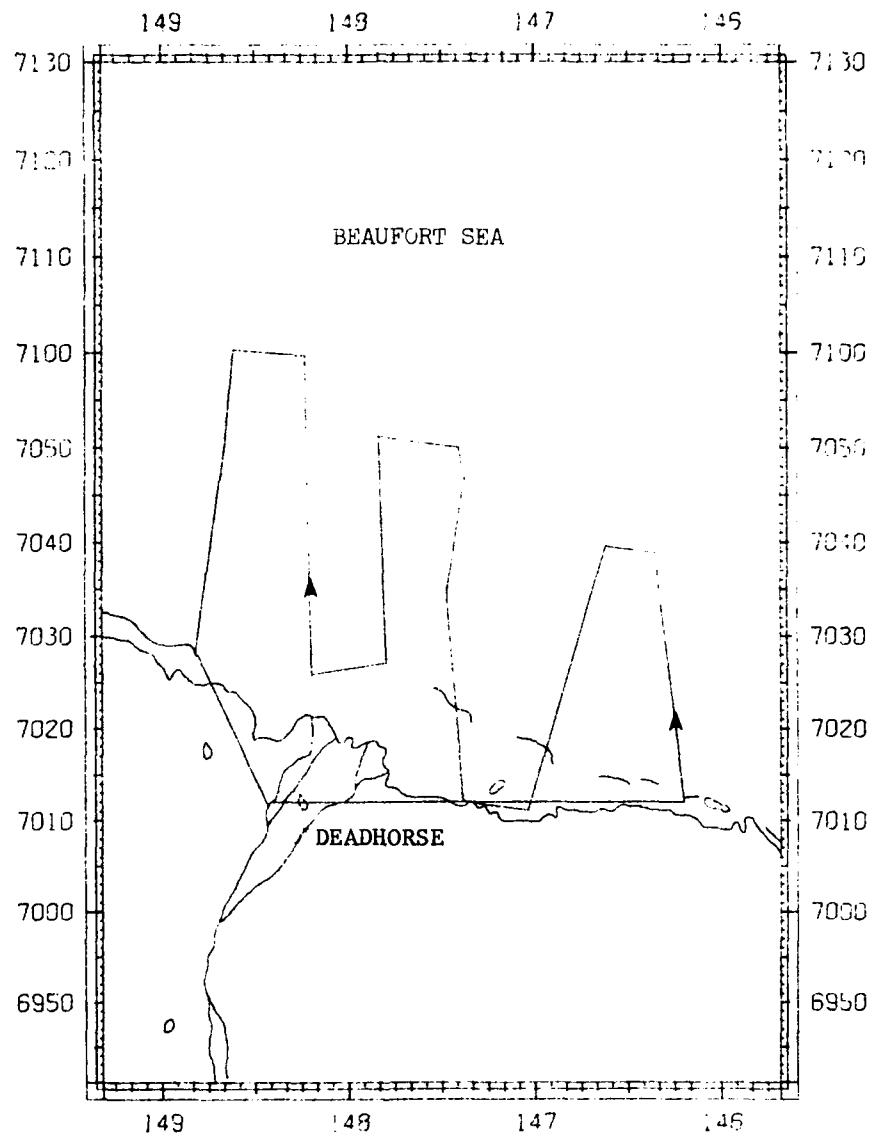
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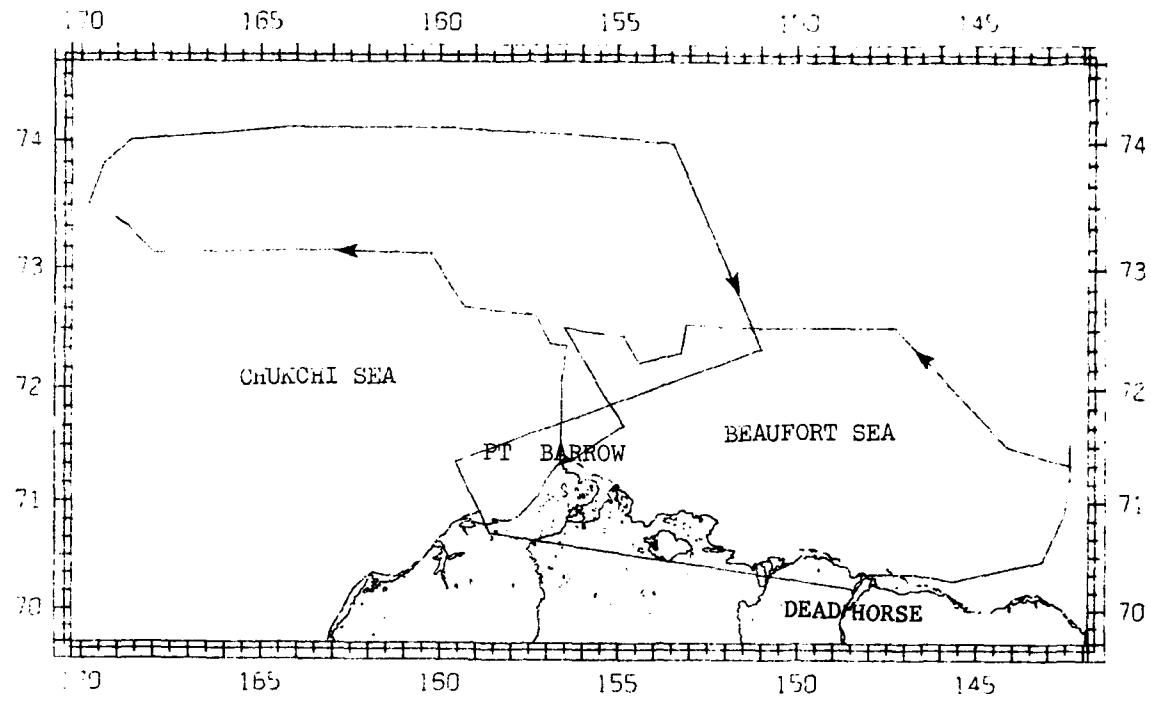




FLIGHT 52. 25 July 1980. Flight included Joint State-Federal lease area. Area was covered with 7/10 ice. One bearded seal and 1 polar bear were sighted.

No bowhead sightings for flight 53, 26 July 1980

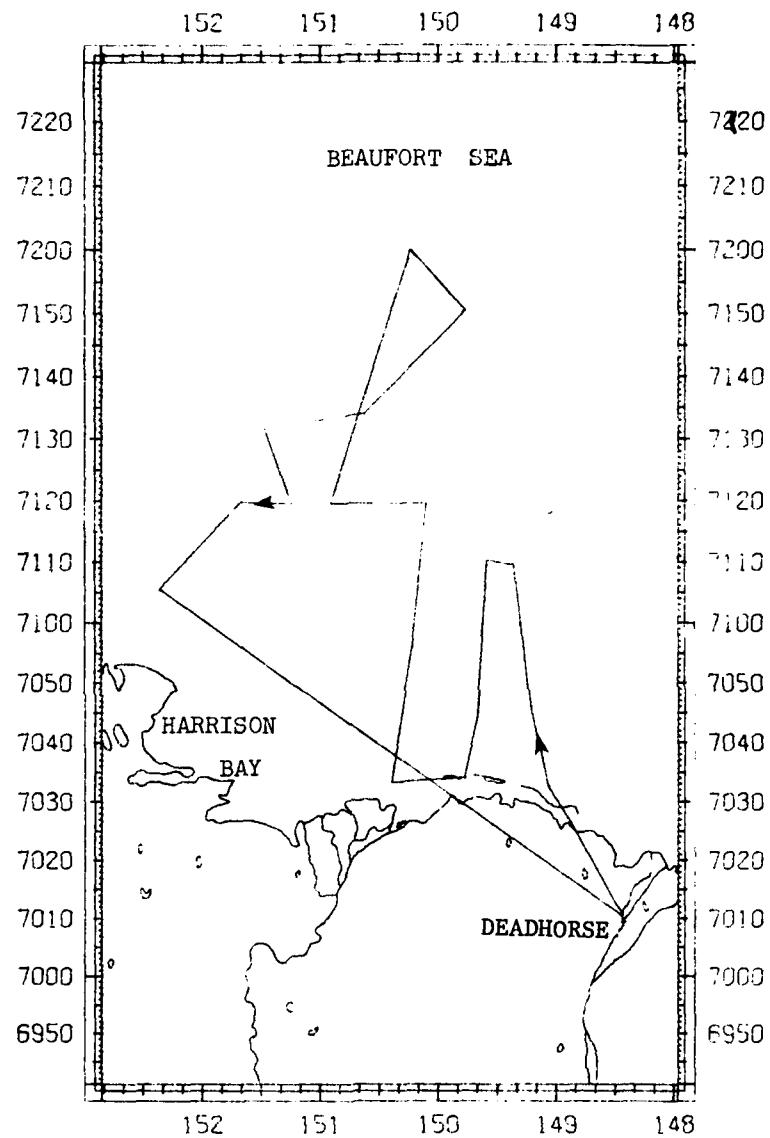
C-102



FLIGHT 53. 26 July 1980. Flight was in support of radio tagging project. One polar bear was sighted.

No bowhead sightings for flight 54, 27 July 1980

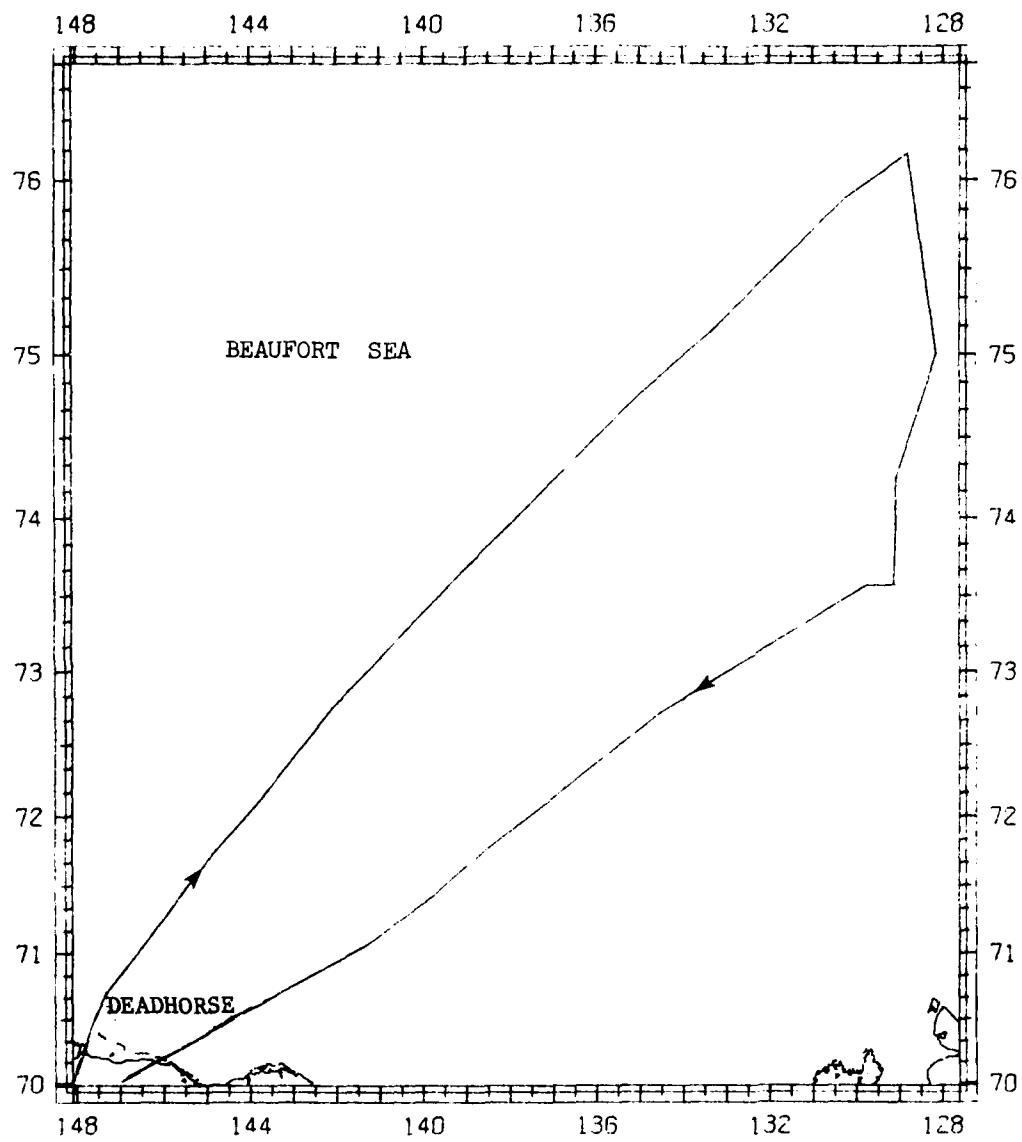
C-104



FLIGHT 54. 27 July 1980. Flight included parts of Federal and Joint State-Federal lease areas. Flight deviated due to fog. No bowheads were sighted. One ring seal was sighted.

No bowhead sightings for flight 55, 28 July 1980

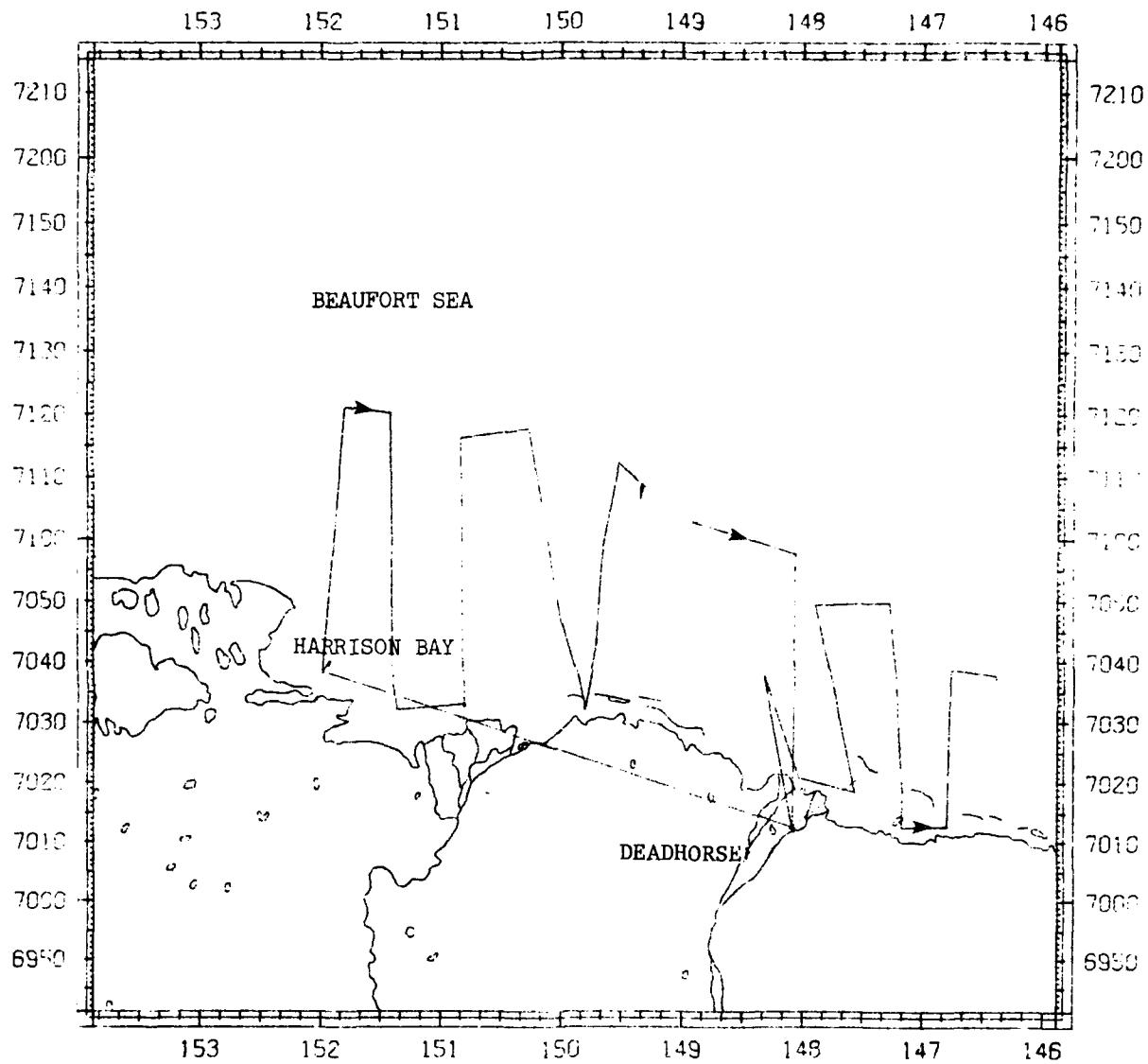
C-106



FLIGHT 55. 28 July 1980. Radio tracking flight between Deadhorse and Banks Island.

C-107

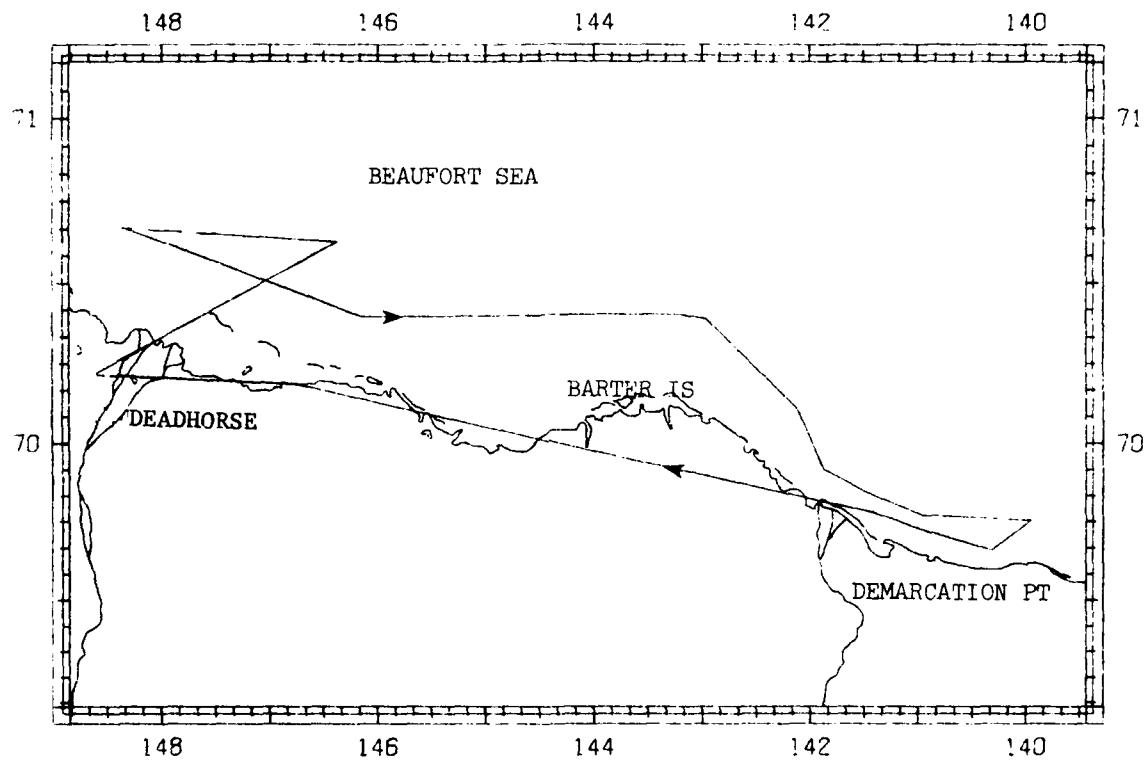
No bowhead sightings for flight 56, 29 July 1980



FLIGHT 56. 29 July 1980. Flight included Federal and Joint State-Federal lease areas. The ice consisted mainly of small and medium floes interspersed with occasional large floes, all with extensive surface puddling. Three ring seals and 1 bearded seal were sighted.

No bowhead sightings for flight 57, 2 August 1980

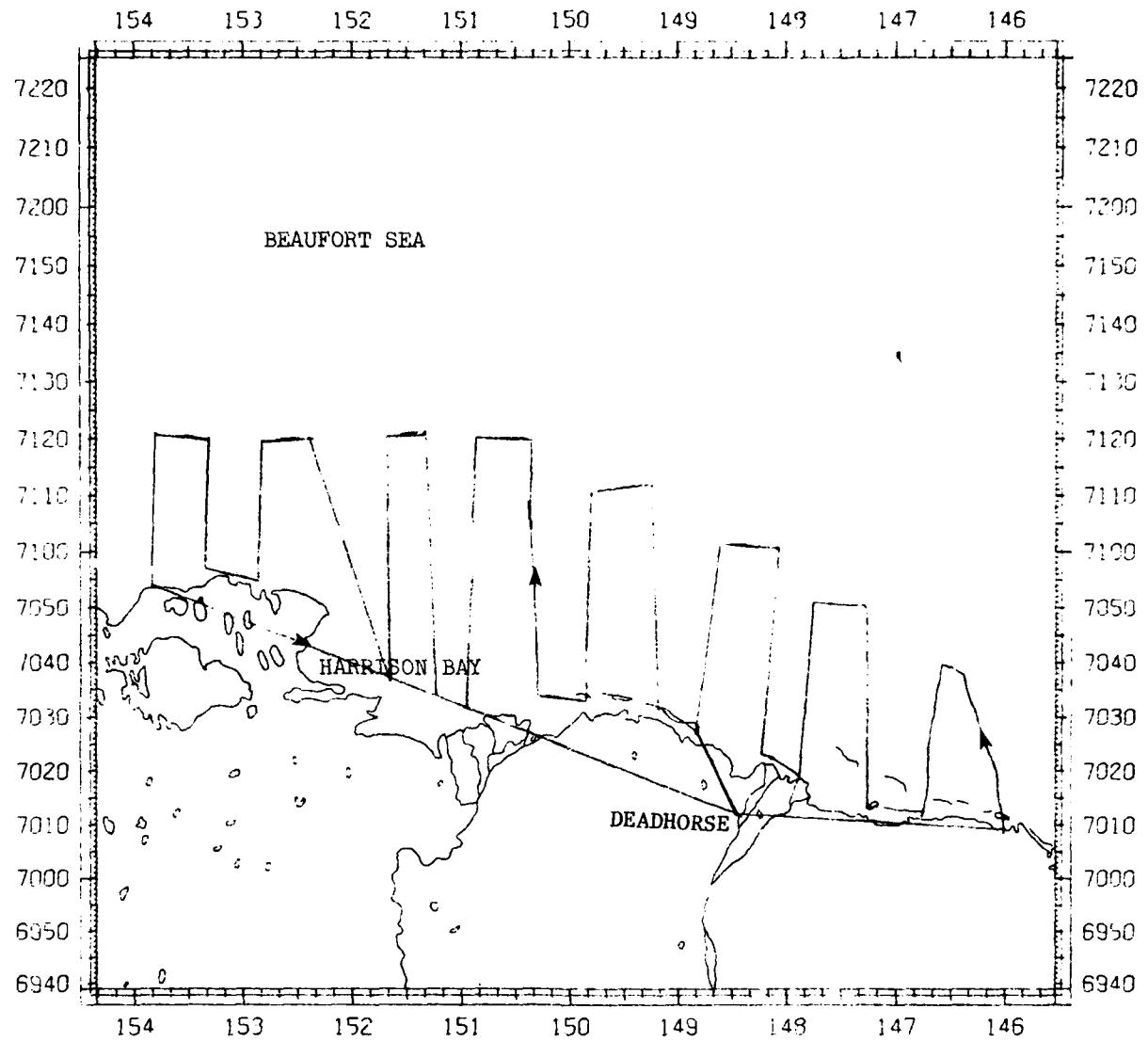
C-110



FLIGHT 57. 2 August 1980. Flight was from Deadhorse east towards Demarcation Point. Ice was 5/10 to 9/10 west of Flaxman Island; eastward the water was open. No sightings were made. Two sonobuoys were dropped. No sounds were recorded.

No bowhead sightings for flight 58, 5 August 1980

C-112



FLIGHT 58. 5 August 1980. Flight included Joint State-Federal and Federal lease areas. Ice consisted mainly of small and medium floes with an occasional large floe, all showing extensive surface puddling. No whales were sighted. Seven ring seals were sighted.

120

C-114

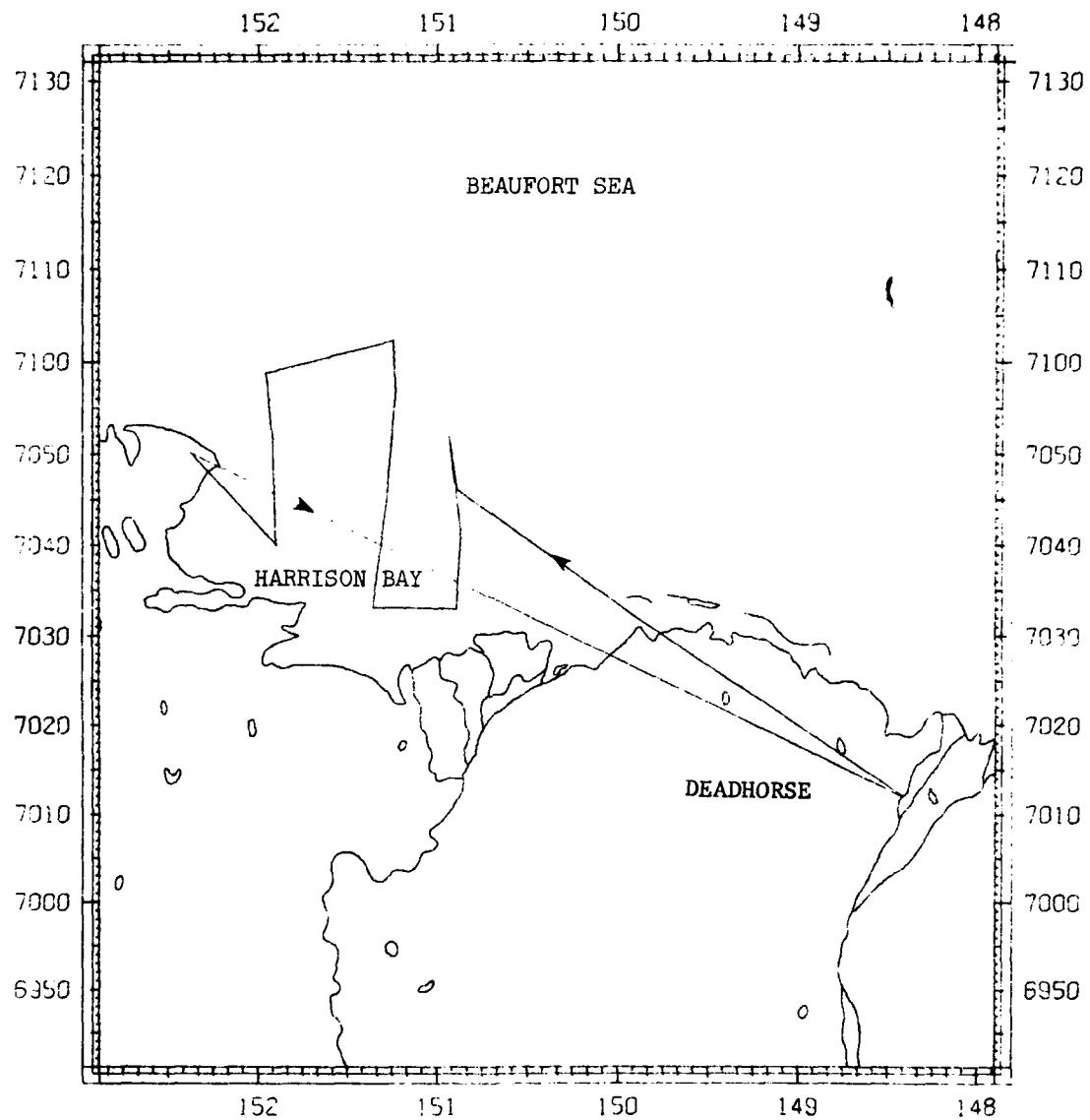
Twenty-two days between 5 August and 27 August were spent in support of the radio tagging project in the eastern Canadian Beaufort Sea.

On 22 August a return flight was made from Tuktoyaktuk to Deadhorse. Brash ice was present offshore from approximately Demarcation Point west to Prudhoe Bay. Numerous groups of pinnipeds and 1 sighting of 3 polar bears, a female with 2 yearling cubs, were made.

Between 22 August and 27 August the aircraft was in Anchorage for maintenance.

No bowhead sightings for flight 59, 27 August 1980

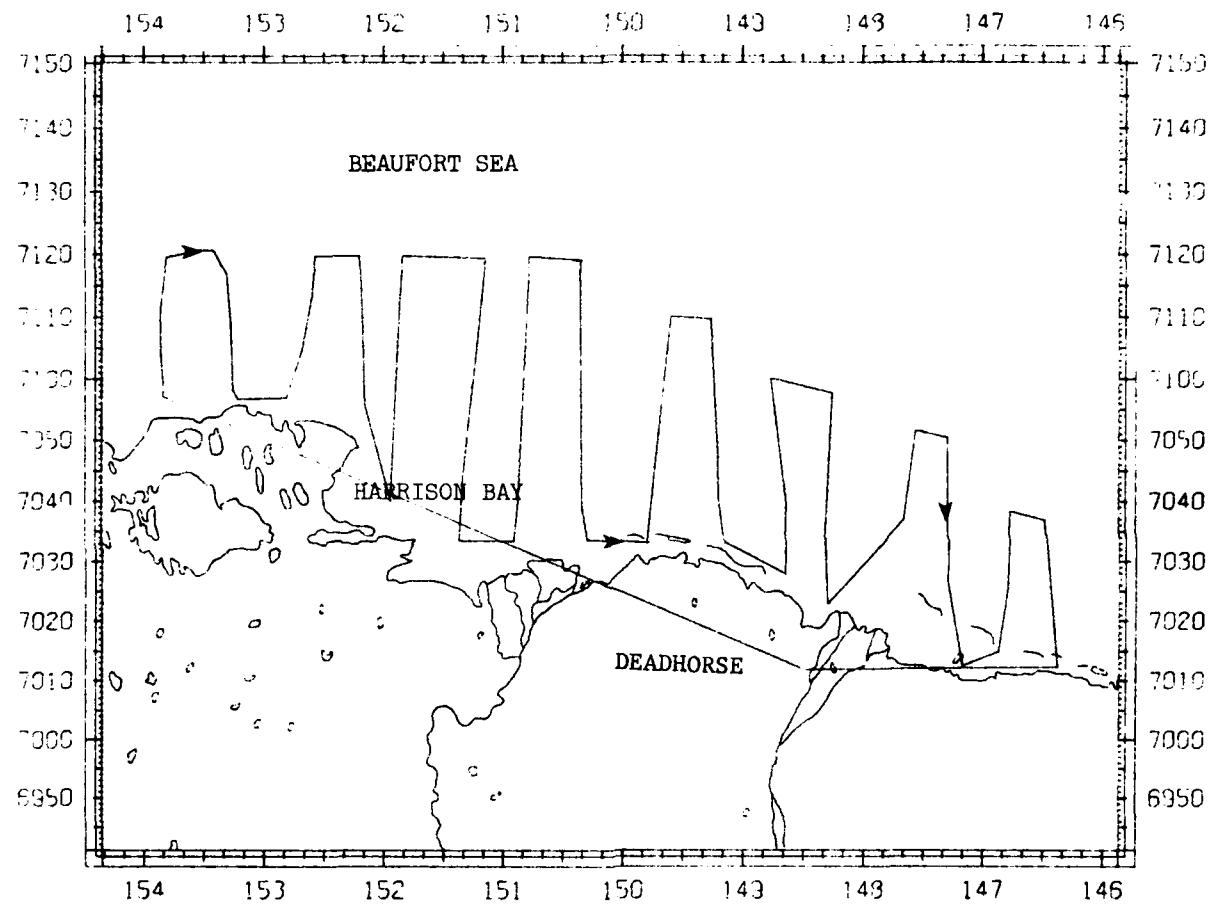
C-116



FLIGHT 59. 27 August 1980. Flight included Harrison Bay in the Federal lease area. No sightings due to restricted weather.

C-117

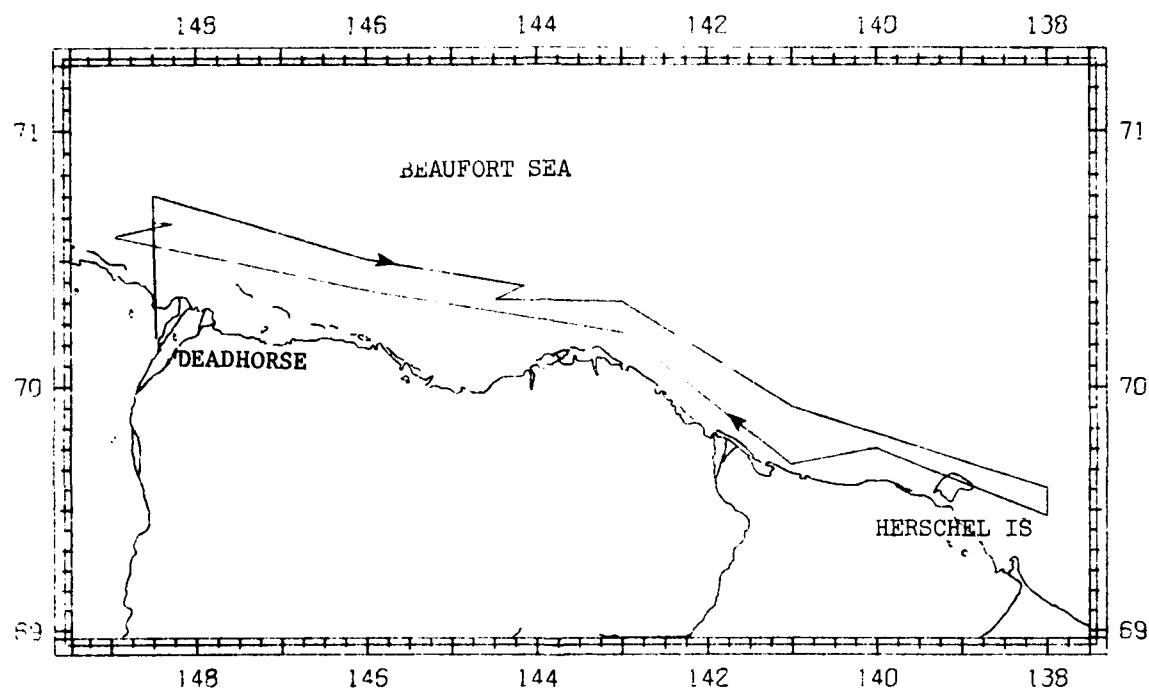
No bowhead sightings for flight 60, 29 August 1980



FLIGHT 60. 29 August 1980. Flight included Federal and Joint State-Federal lease areas. Ice coverage ranged from 1/10 to 9/10, but averaged 5/10. One ring seal was sighted.

No bowhead sightings for flight 61, 30 August 1980

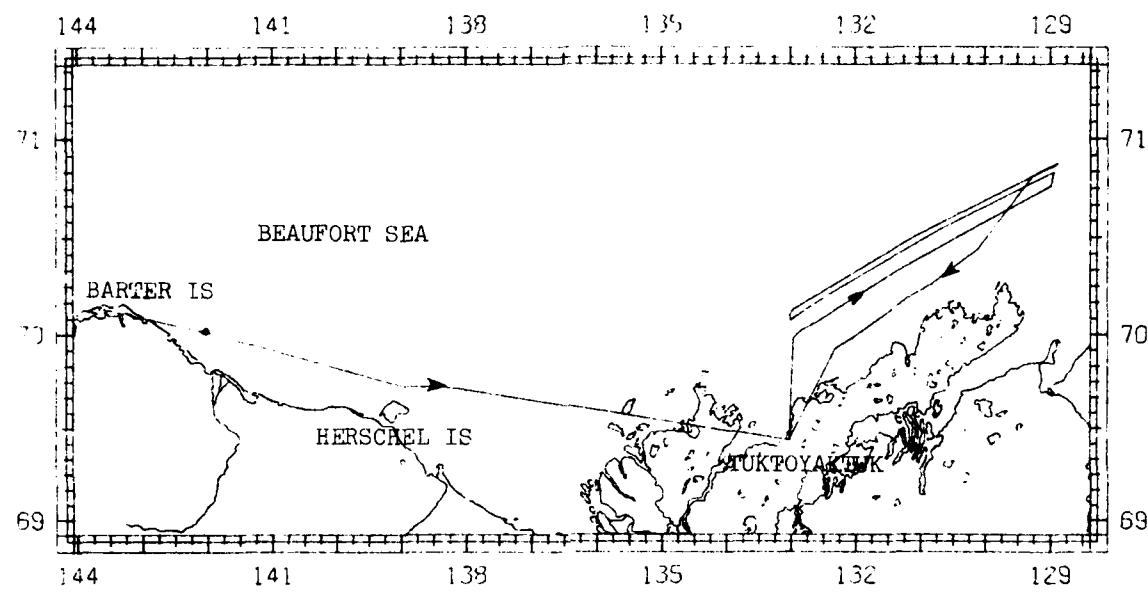
C-120



FLIGHT 61. 30 August 1980. Flight was from Deadhorse to Herschel Island. Brash ice and old broken floes were present with 5/10 to 7/10 coverage. There was open water around Herschel Island. Six ring seals and 1 polar bear were sighted.

Bowhead Whale Sightings for Flight 62, 4 September 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	142-013	70-00.9	180		NE-070	7/10 ice, 5 km off shore
TOTAL 1						

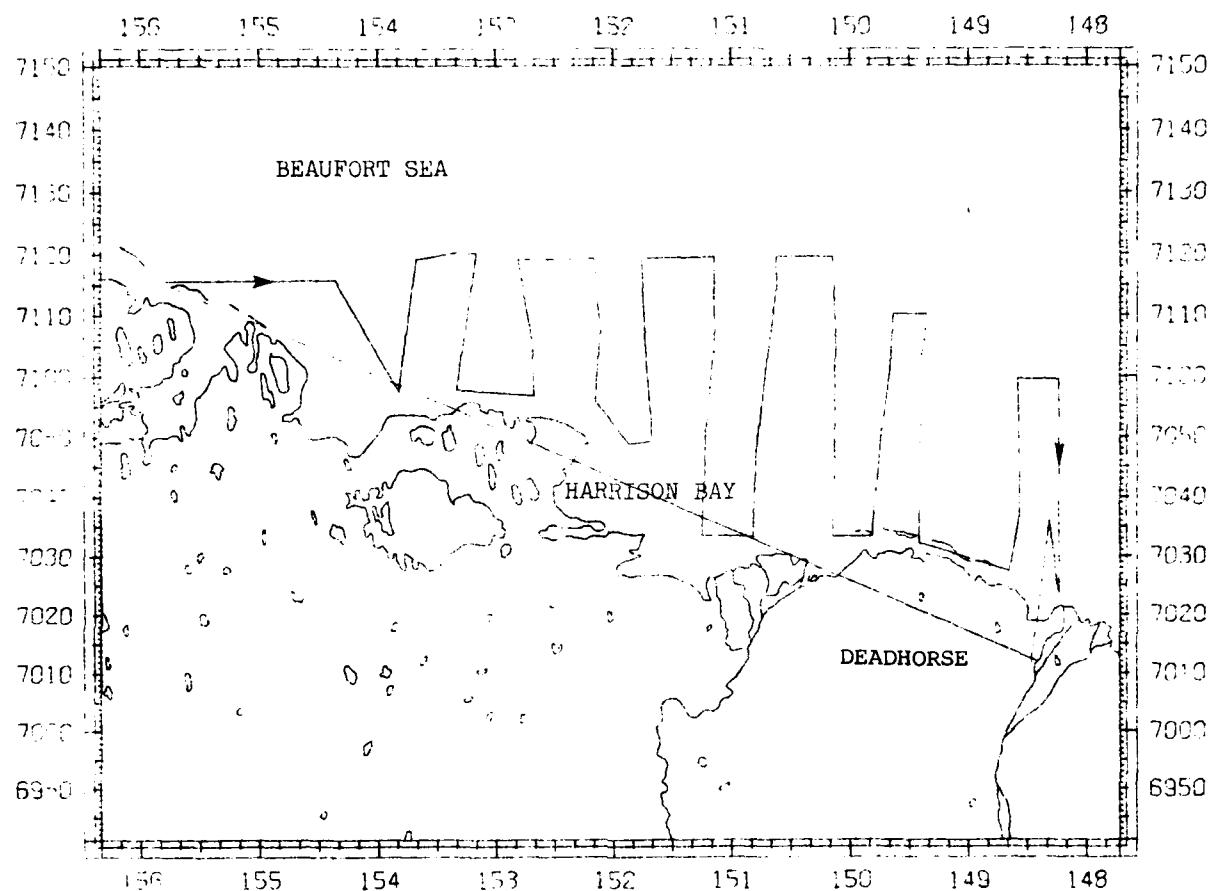


FLIGHT 62. 4 September 1980. Flight was from Deadhorse to Tuktoyaktuk in support of radio tagging project. One bowhead was sighted.

C-123

No bowhead sightings for flight 63, 5 September 1980

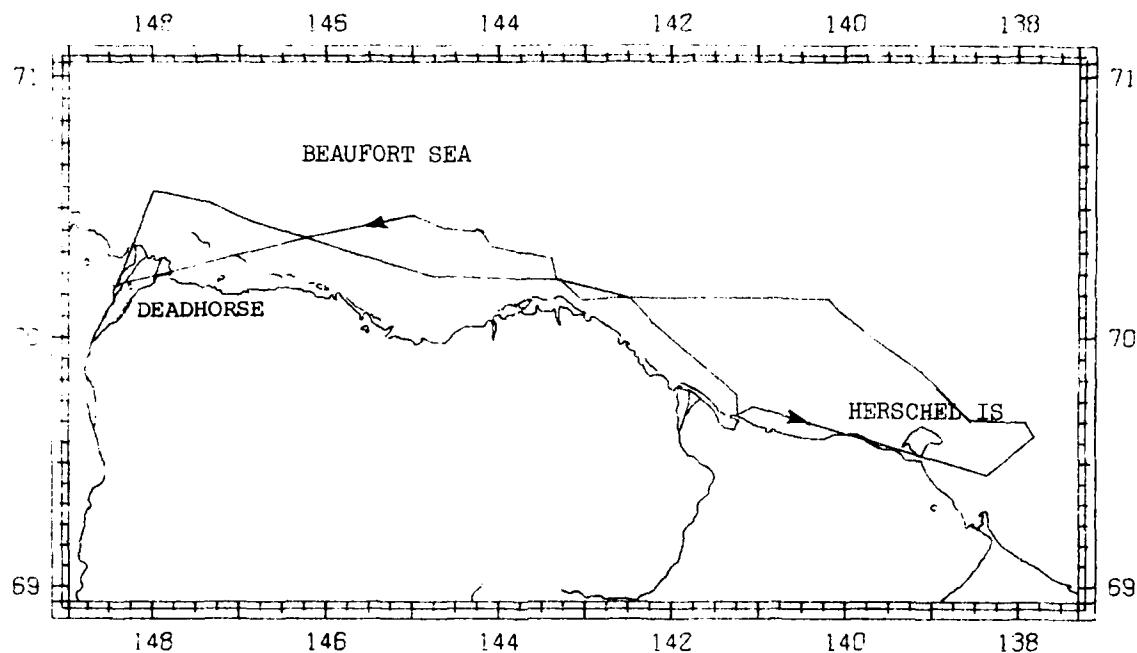
C-124



FLIGHT 63. 5 September 1980. Flight included Federal and Joint State-Federal lease areas. One pinniped was sighted. Brash ice and old floe ice coverage ranged from 1/10 to 8/10.

No bowhead sightings for flight 64, 8 September 1980

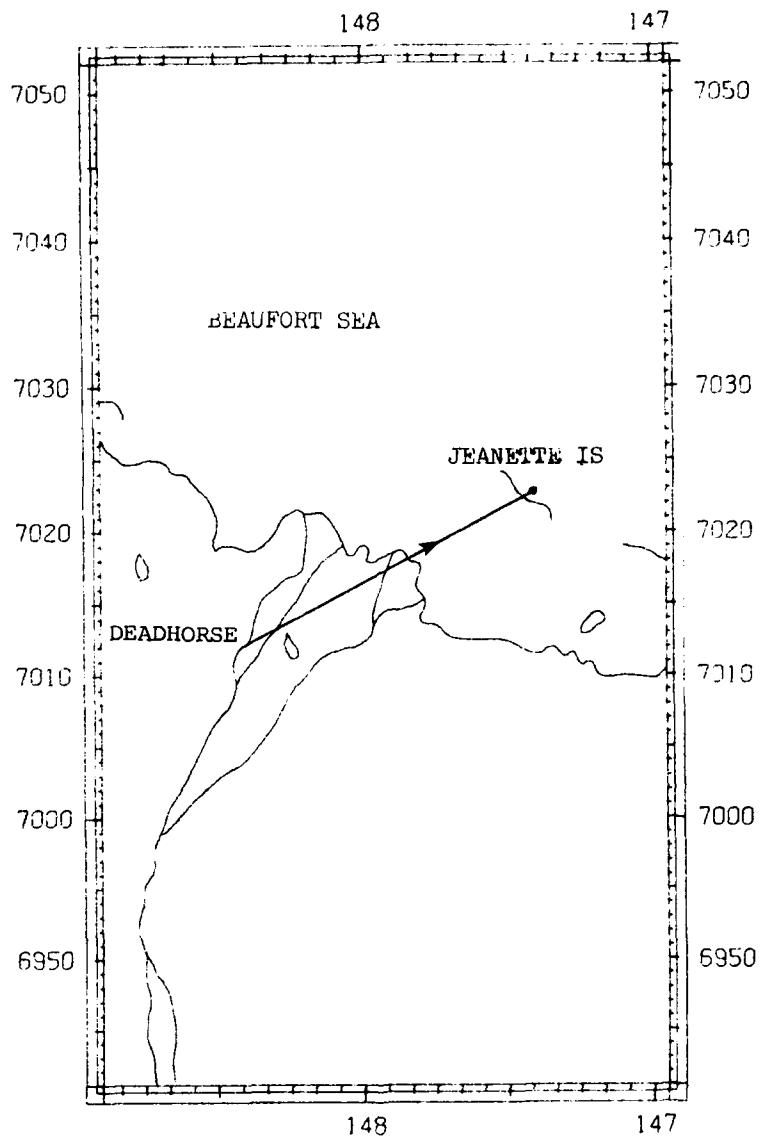
C-126



FLIGHT 64. 8 September 1980. Flight was from Deadhorse east to Herschel Island and back to Deadhorse. Brash ice and broken floe ice were present throughout the entire transect in concentrations that ranged from 1/10 to 9/10 coverage. The ice was close to shore from Barter Island east to Herschel Island. Brash ice completely encircled Herschel Island and was present in Pauline Cove. One dead beluga and 1 group of 3 polar bears were sighted.

Bowhead Whale Sightings for Flight 65, 9 September 1980

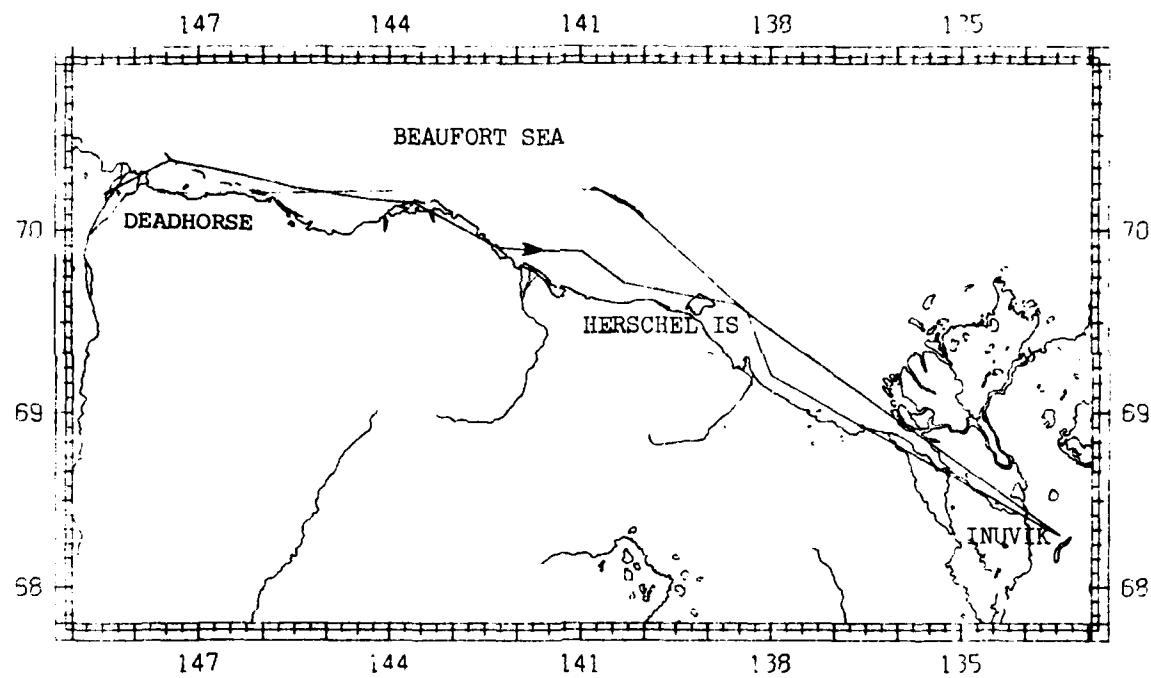
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
2	147-27.6	71-27.2			W-270	Sighted from Jeanette Island
TOTAL 2						



FLIGHT 65. 9 September 1980. Flight was to Jeanette Island to photograph the stranded bowhead. Two bowheads were sighted from the island 1 km offshore, heading west at an estimated speed of 1.5 kn. Fog prevented resighting of those whales from the air.

No bowhead sightings for flight 66, 10 September 1980

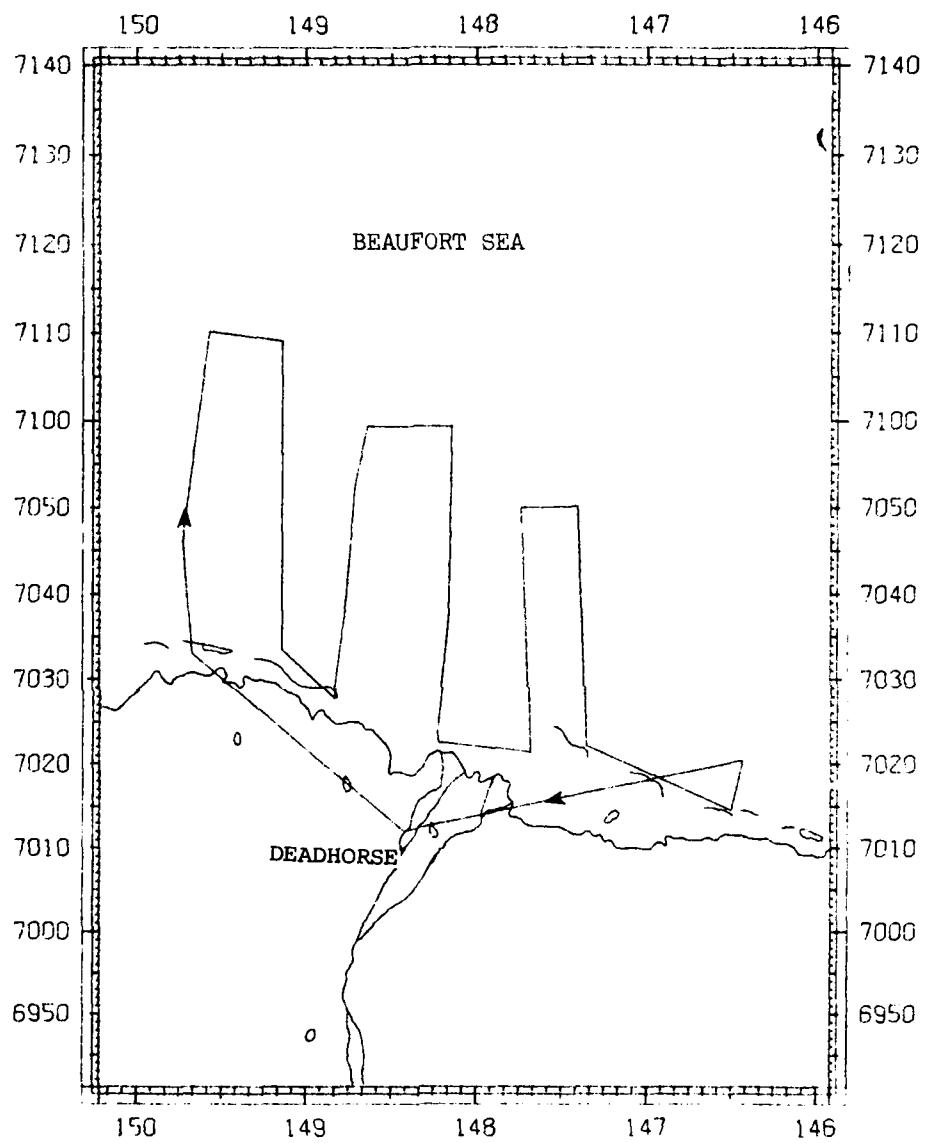
C-130



FLIGHT 66. 10 September 1980. Flight was from Deadhorse to Inuvik and back to Deadhorse with a stop at Beaufort Lagoon. Ice coverage varied from 2/10 to 9/10. One ring seal was sighted.

No bowhead sightings for flight 67, 11 September 1980

C-132

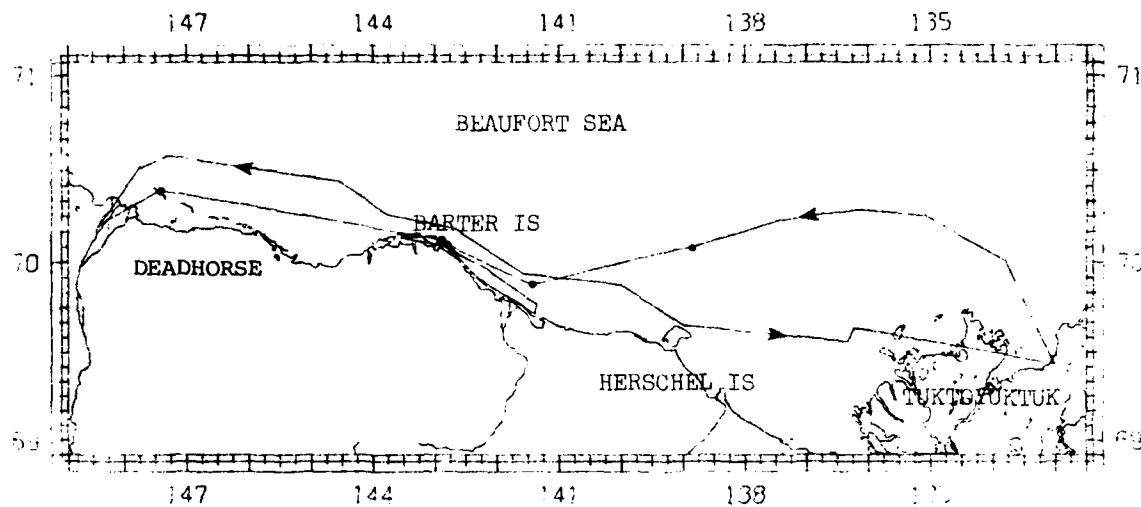


FLIGHT 67. 11 September 1980. Flight included the Joint State-Federal lease area. Flight was aborted due to fog. No sightings.

Bowhead Whale Sightings for Flight 68, 14 September 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	138-50.4	70-04.6	450	22	SW-250	10 meters long
1	141-25.8	69-52.8	400	45	S-180	Possible feeding activity
3	142-47.6	70-05.8	400	23	E-90	Mud trails in water, possible feeding activity
1	142-53.5	70-06.6	400	23	E-90	3 km from shore, possible feeding activity
1	142-43.4	70-03.4	360	18	S-180	
1	142-43.4	70-03.4	360	40	SE-160	
1	142-52.6	70-07.4	400	38		Dead bowhead, whale boat alongside

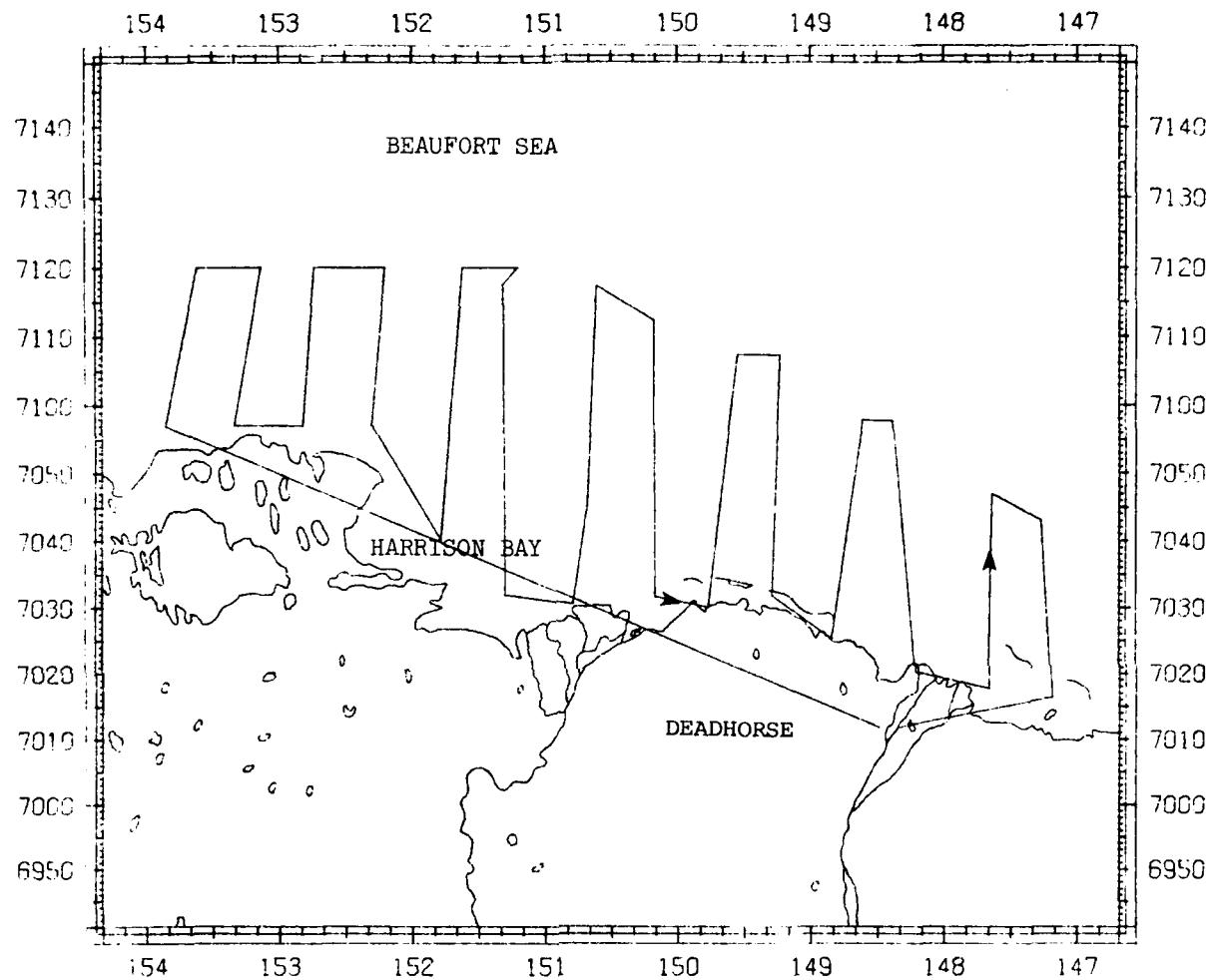
TOTAL 9



FLIGHT 68. 14 September 1980. Flight was from Deadhorse to Tuktoyaktuk and back to Deadhorse via Barter Island, Beaufort Lagoon. Nine bowheads were sighted near the coast just east of Barter Island. Eskimos had taken 1 whale. There was evidence of feeding by other whales.

No bowhead sightings for flight 69, 15 September 1980

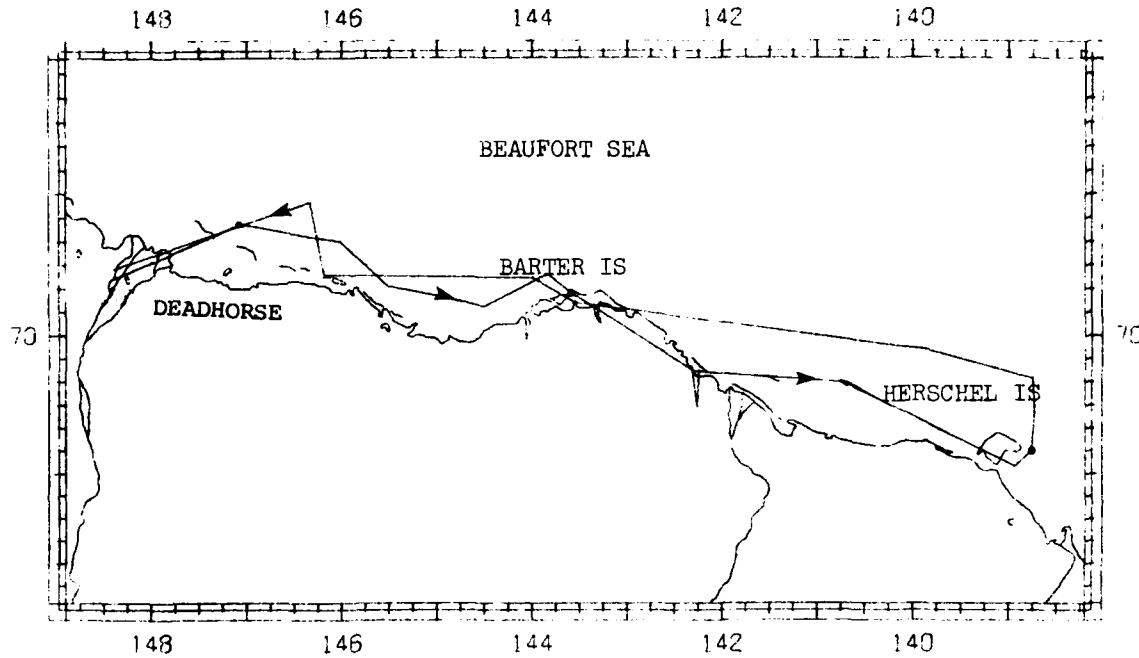
C-136



FLIGHT 69. 15 September 1980. Flight included the Federal and Joint State-Federal lease areas. No sightings.

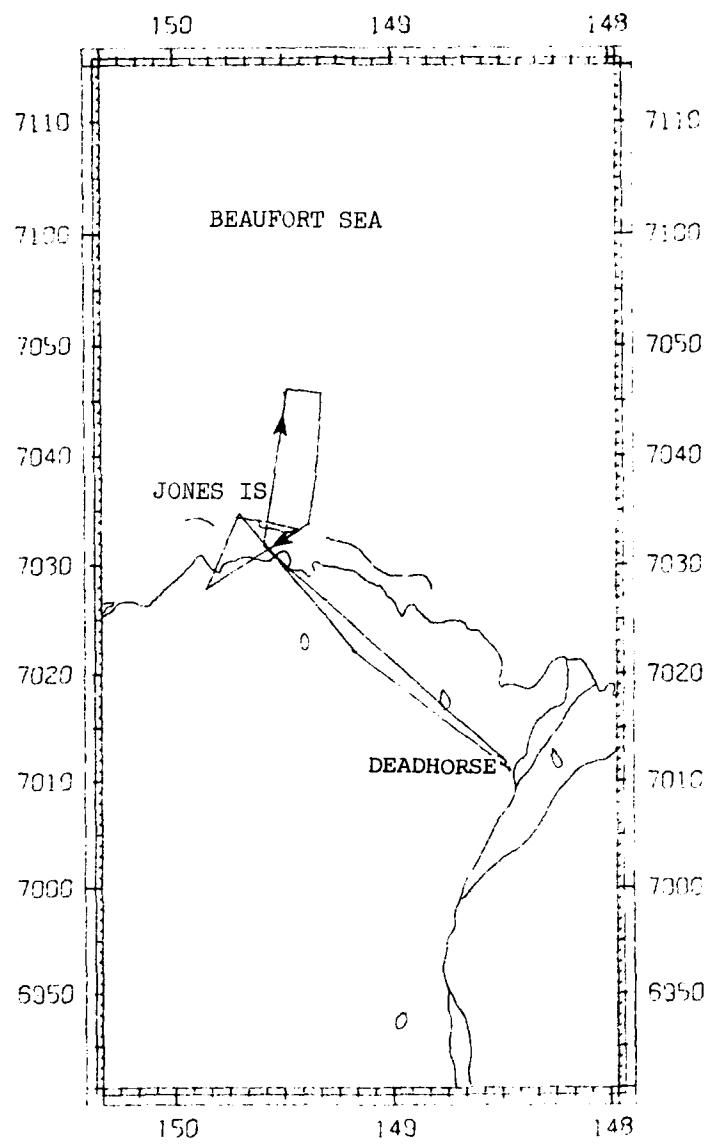
Bowhead Whale Sightings for Flight 70, 16 September 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	147-04.4	70-23.6	300	18	NW-315	Swimming in open water
3	138-45.5	69-35.6	160	12	N-360	All dove
TOTAL 4						



FLIGHT 70. 16 September 1980. Flight was from Deadhorse to Beaufort Lagoon along the 10-fathom line. One bowhead was sighted on the surface heading north. Flight continued from Beaufort Lagoon east to Herschel Island. Three bowheads were sighted 1 km northwest of Herschel Island. Flew Joint State-Federal lease area on return.

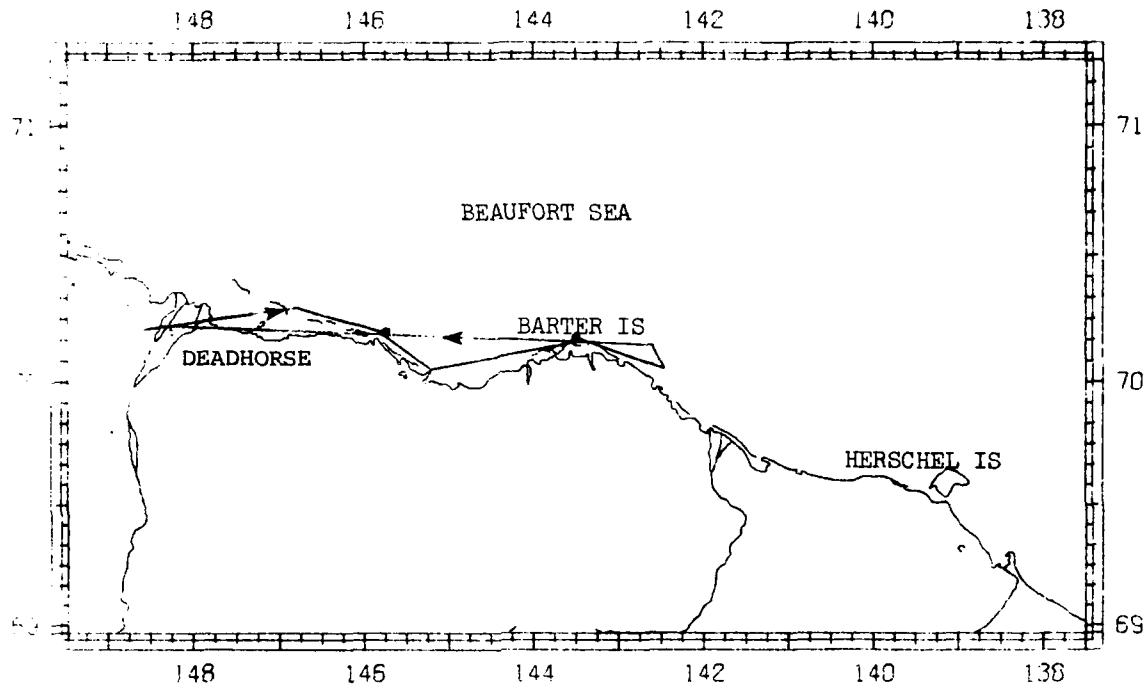
No bowhead sightings for flight 71, 17 September 1980



FLIGHT 71. 17 September 1980. Flight included the Joint State-Federal lease area but was aborted due to heavy fog.

Bowhead Whale Sightings for Flight 72, 18 September 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	145-52.0	70-11.5	300	51	W-270	Dove, 3 km off Flaxman Island
4	143-30.0	70-00.5	300		E-090	Dove, possible repeat sightings, one had white coloration on head with brownish body
TOTAL 5						

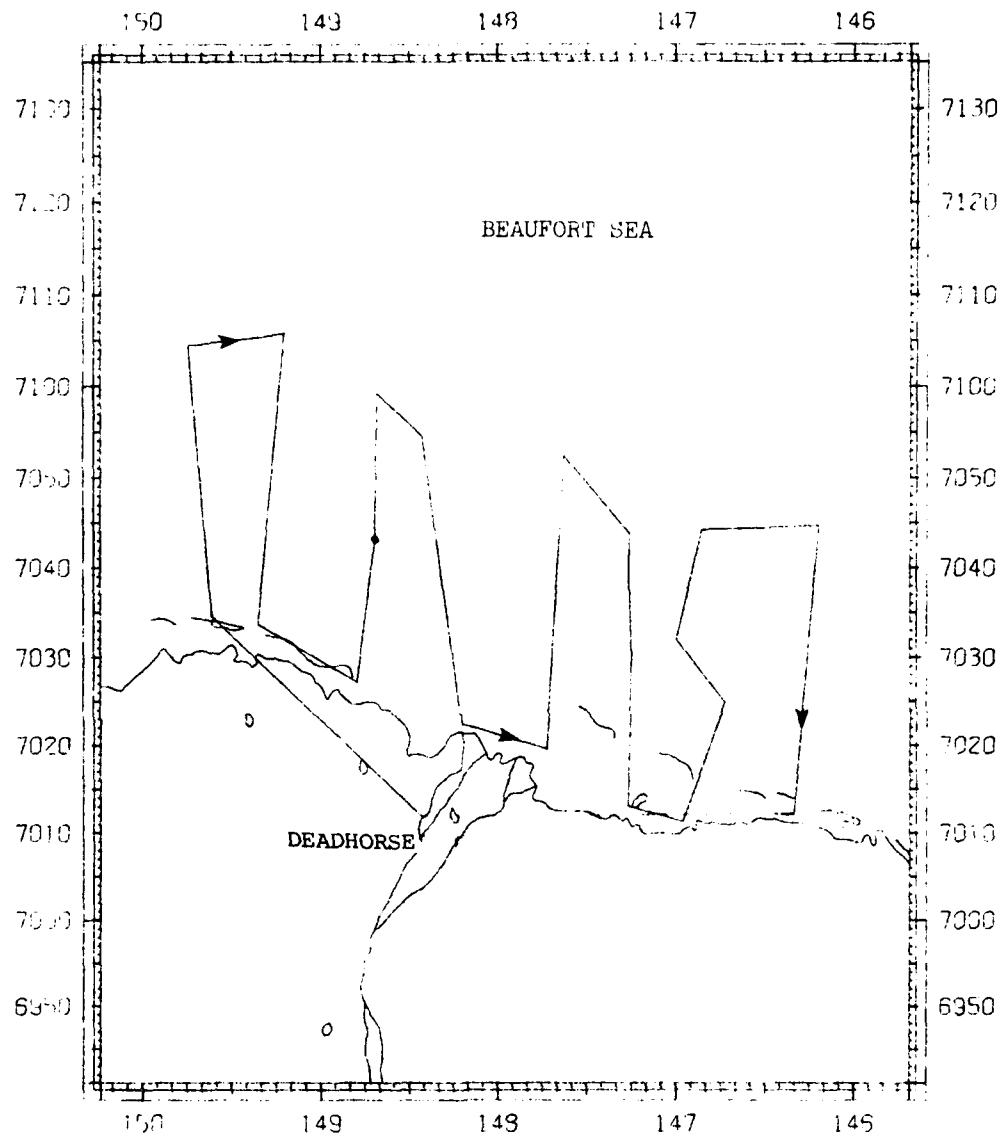


FLIGHT 72. 18 September 1980. Flight was from Deadhorse to Beaufort Lagoon. One bowhead heading west was sighted east of Flaxman Island. Four bowheads were sighted about 3 km north of Beaufort Lagoon. One of these was brown with white or gray head. No sightings on return flight to Deadhorse.

C-143

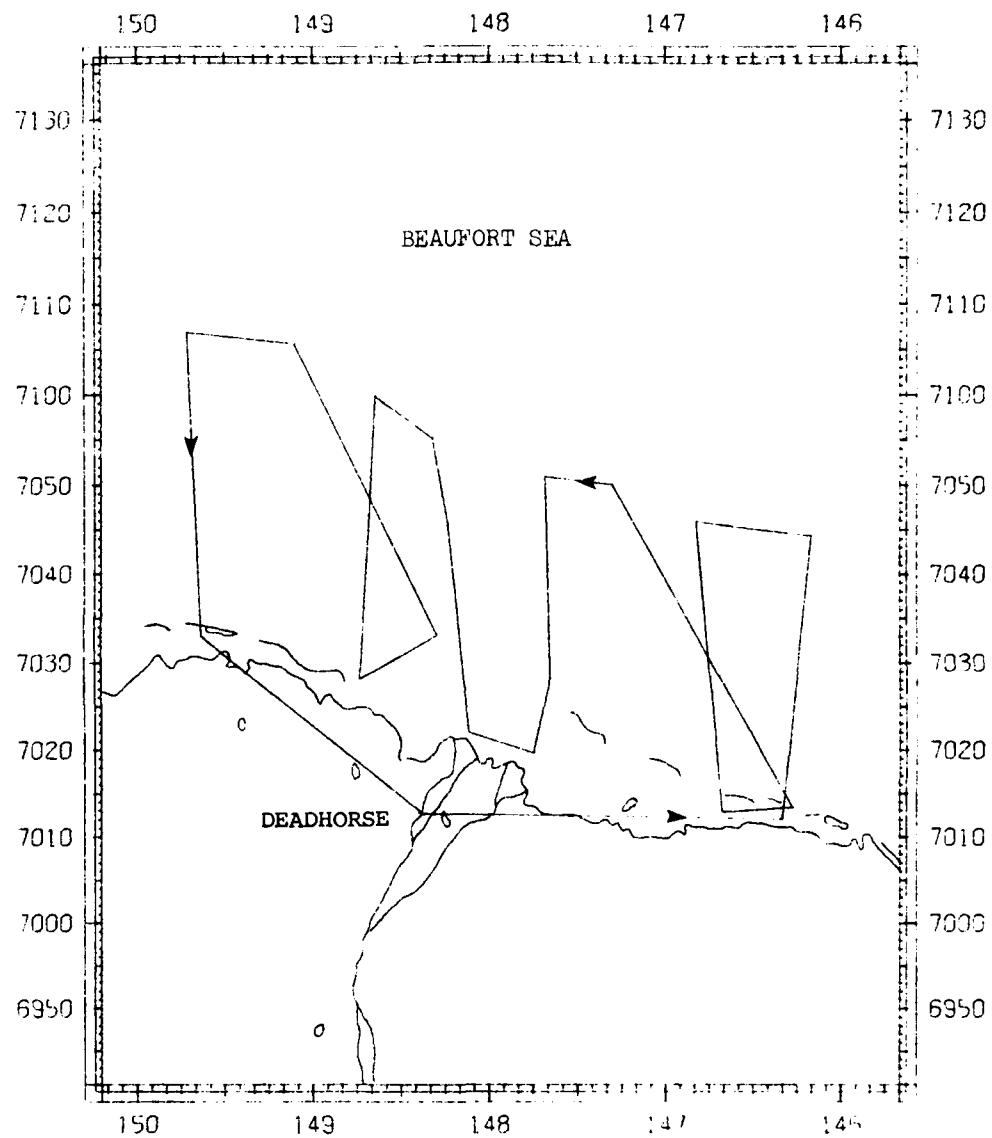
Bowhead Whale Sightings for Flight 73, 20 September 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	148-46.5	70-43.2	100	12	NW-315	Dove
TOTAL 1						



FLIGHT 73. 20 September 1980. Flight included the Joint State-Federal lease area. One bowhead was sighted heading northwest. A sonobuoy was dropped which transmitted a couple of bowhead sounds. One polar bear was sighted. Ice coverage estimated at 7/10.

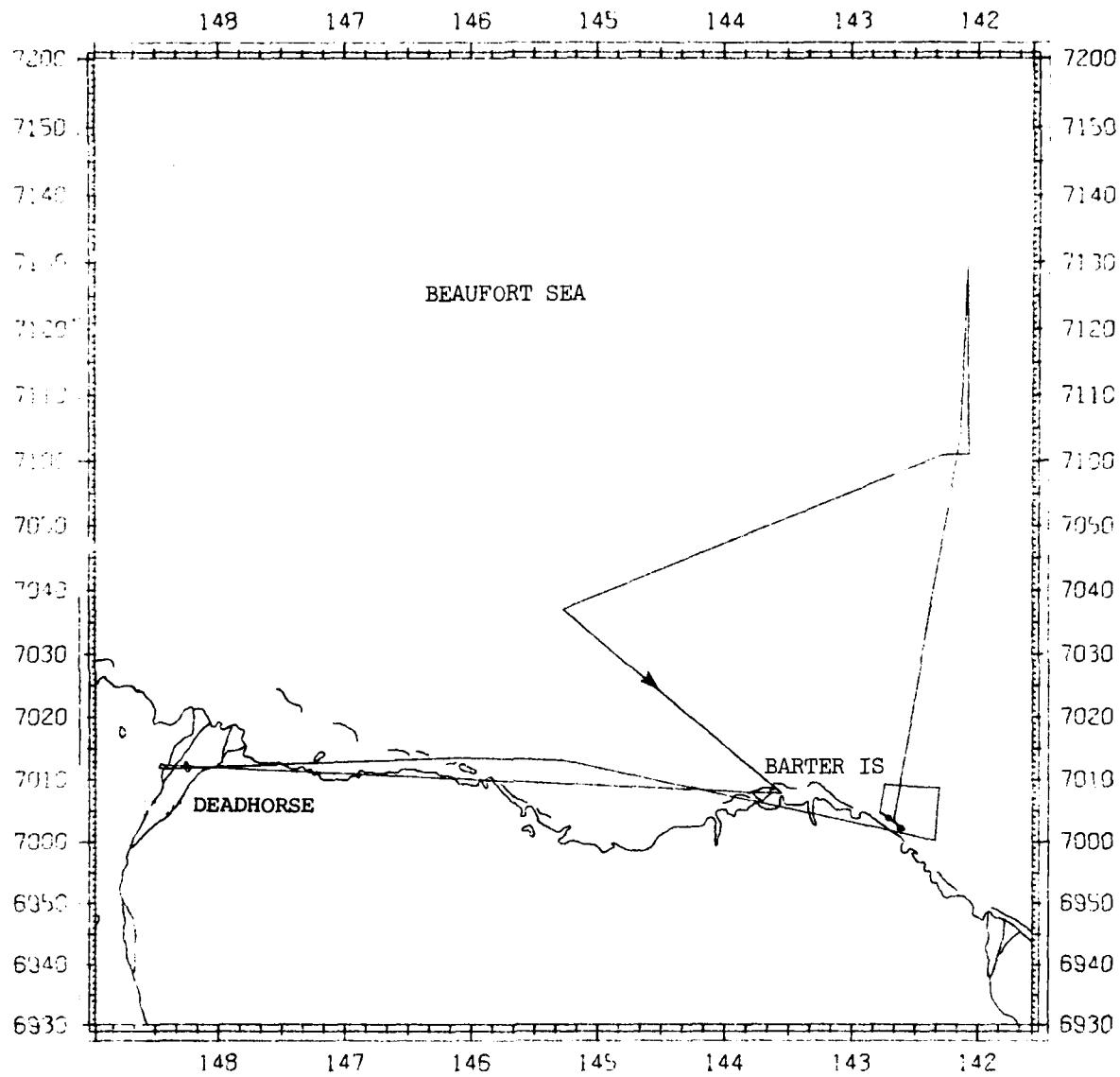
No bowhead sightings for flight 74, 20 September 1980



FLIGHT 74. 20 September 1980. Flight included Joint State-Federal lease area. Dropped three sonobuoys and recorded bowhead sounds. Pack ice was at approximately 71°08' N. Extensive new ice present. No sightings.

Bowhead Whale Sightings for Flight 75, 21 September 1980

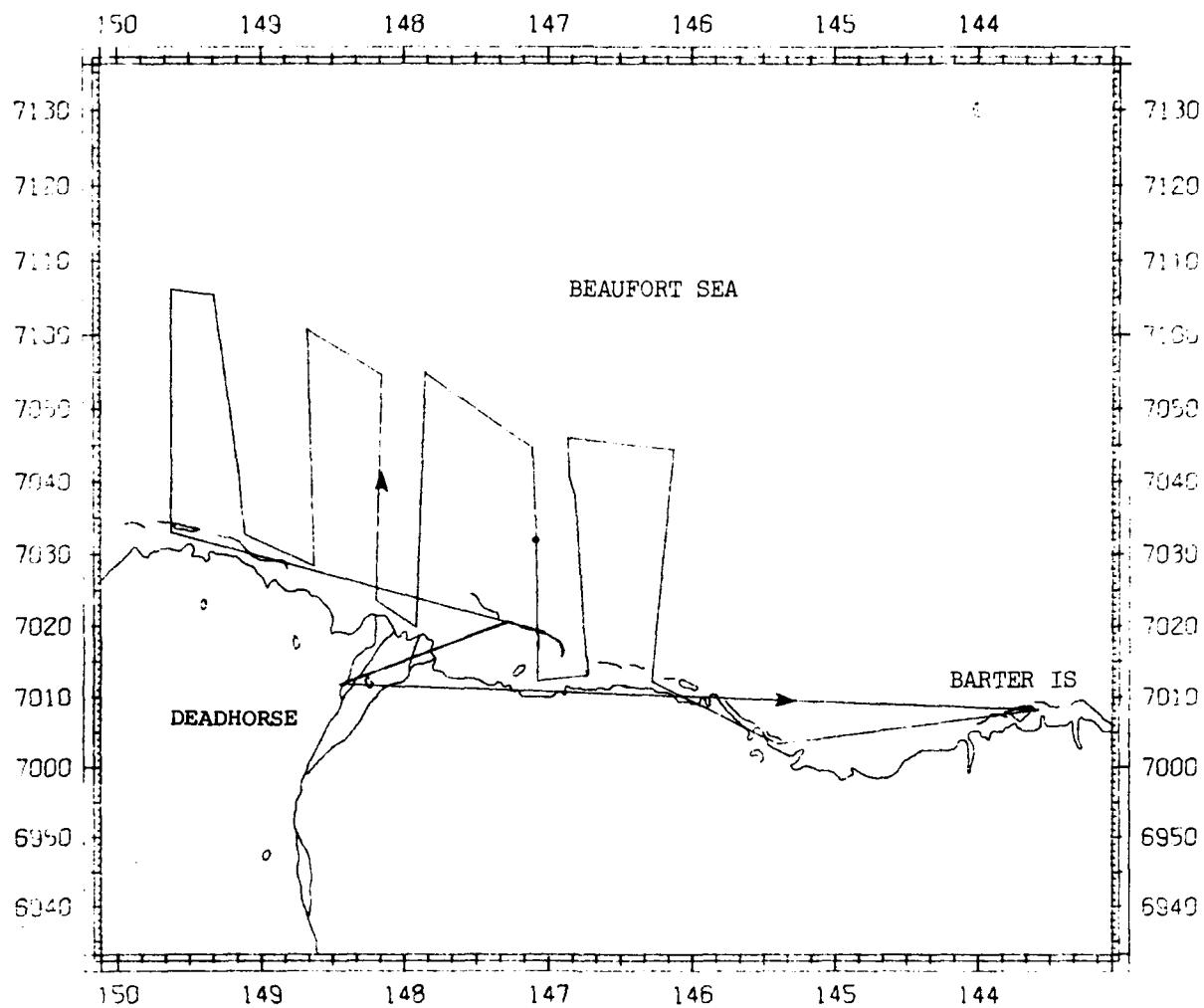
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	142-42.0	70-03.6	300			
1	142-36.5	70-02.1	300			Dove
TOTAL 2						



FLIGHT 75. 21 September 1980. Flight was from Deadhorse to Beaufort Lagoon, then north to the pack ice at $71^{\circ}28' N$. Two bowheads which appeared to be feeding were sighted 1 km north of the lagoon. A sonobuoy was dropped but no sounds were recorded. No sightings were made on return leg to Deadhorse. One polar bear was sighted.

Bowhead Whale Sightings for Flight 76, 22 September 1980

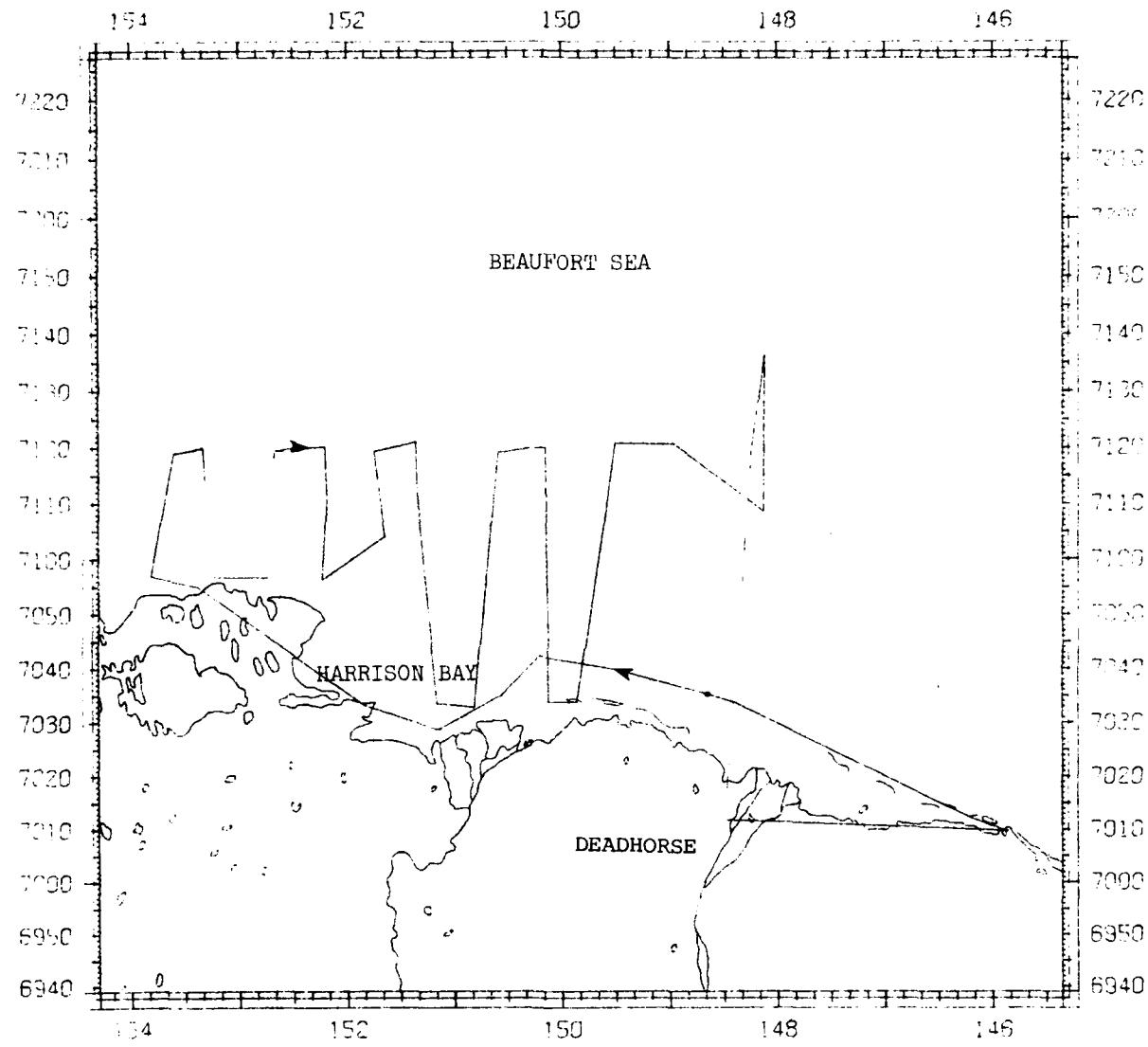
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	147-05.0	70-31.8	120	5	NE-300	In grease ice
TOTAL 1						



FLIGHT 76. 22 September 1980. Flight was from Deadhorse east to Barter Island to assist and supply the food study project. Survey included the Joint State-Federal lease area. One bowhead heading west was sighted. Ice coverage was 7/10 in most areas. One ring seal was sighted.

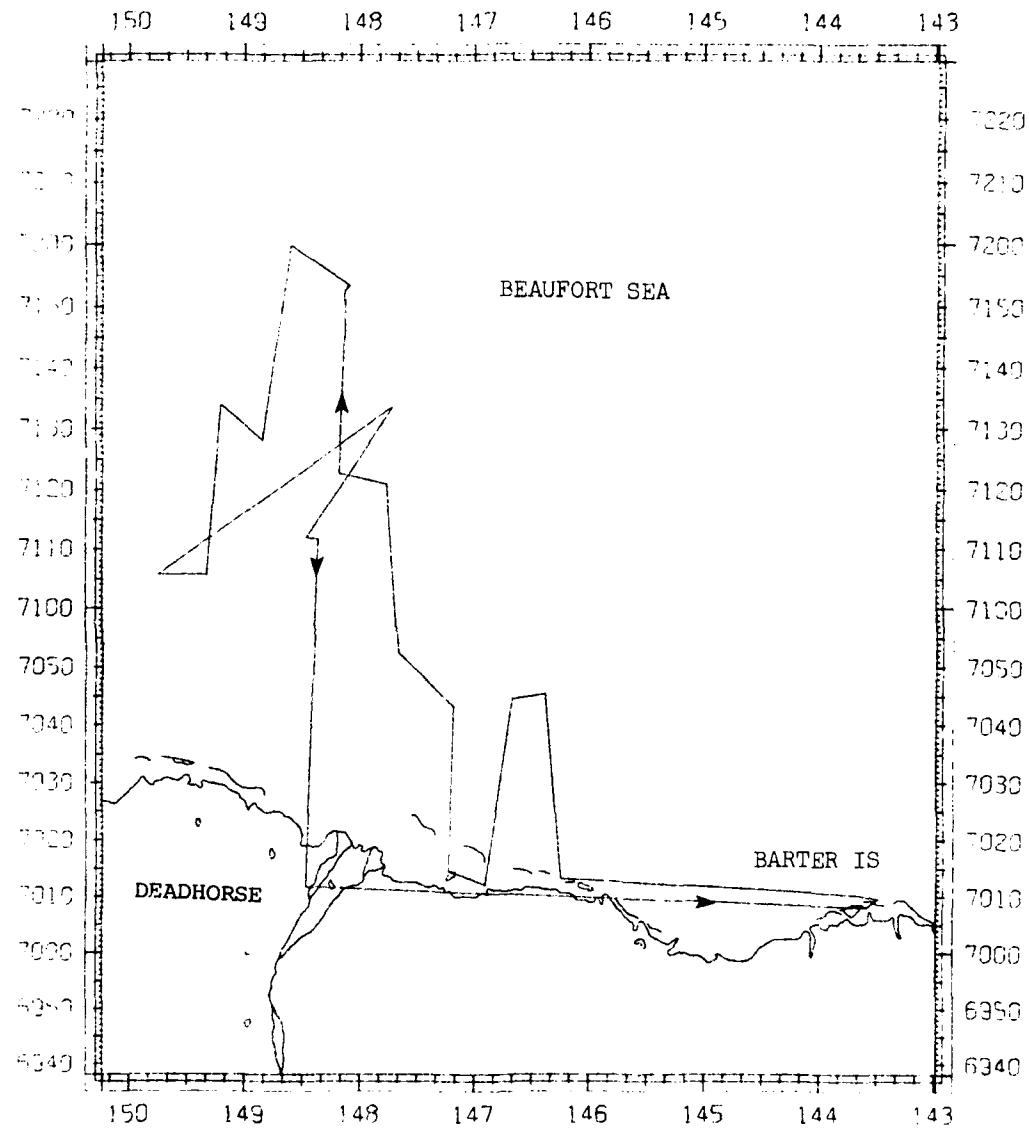
Bowhead Whale Sightings for Flight 77, 23 September 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	148-39.2	70-35.3	300	9	NW-300	In grease ice, dove
TOTAL 1						



FLIGHT 77. 23 September 1980. Flight was from Deadhorse east to support the food study project, then west to survey the Federal lease area. One bowhead was sighted, heading northwest. Eight polar bears and 3 bearded seals were sighted. Ice coverage was 7/10.

No bowhead sightings for flight 78, 24 September 1980

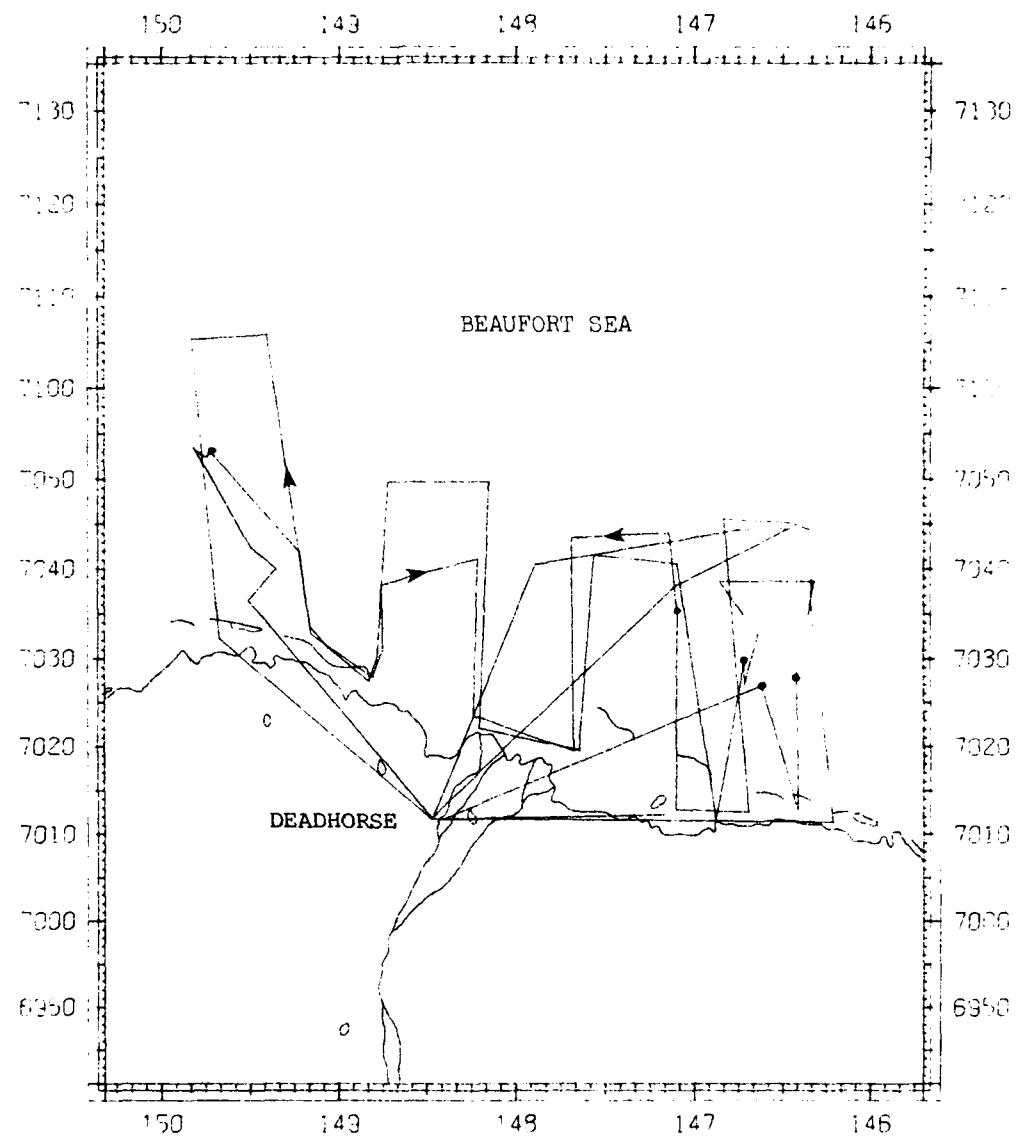


FLIGHT 78. 24 September 1980. Flight included the Joint State-Federal lease area. Two polar bears were sighted.

Bowhead Whale Sightings for Flight 79, 25 September 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	147-05.6	70-35.3	300	11	NW-300	Dove after 2 blows
2	149-42.7	70-53.1	200	12	NW-300	White coloration on heads, dove
2	146-47.8	70-29.8	300	12	SW-240	In lead, dove
1	146-25.1	70-27.8	300	30	SW-240	
1	146-37.0	70-76.9	150	40	SW-240	

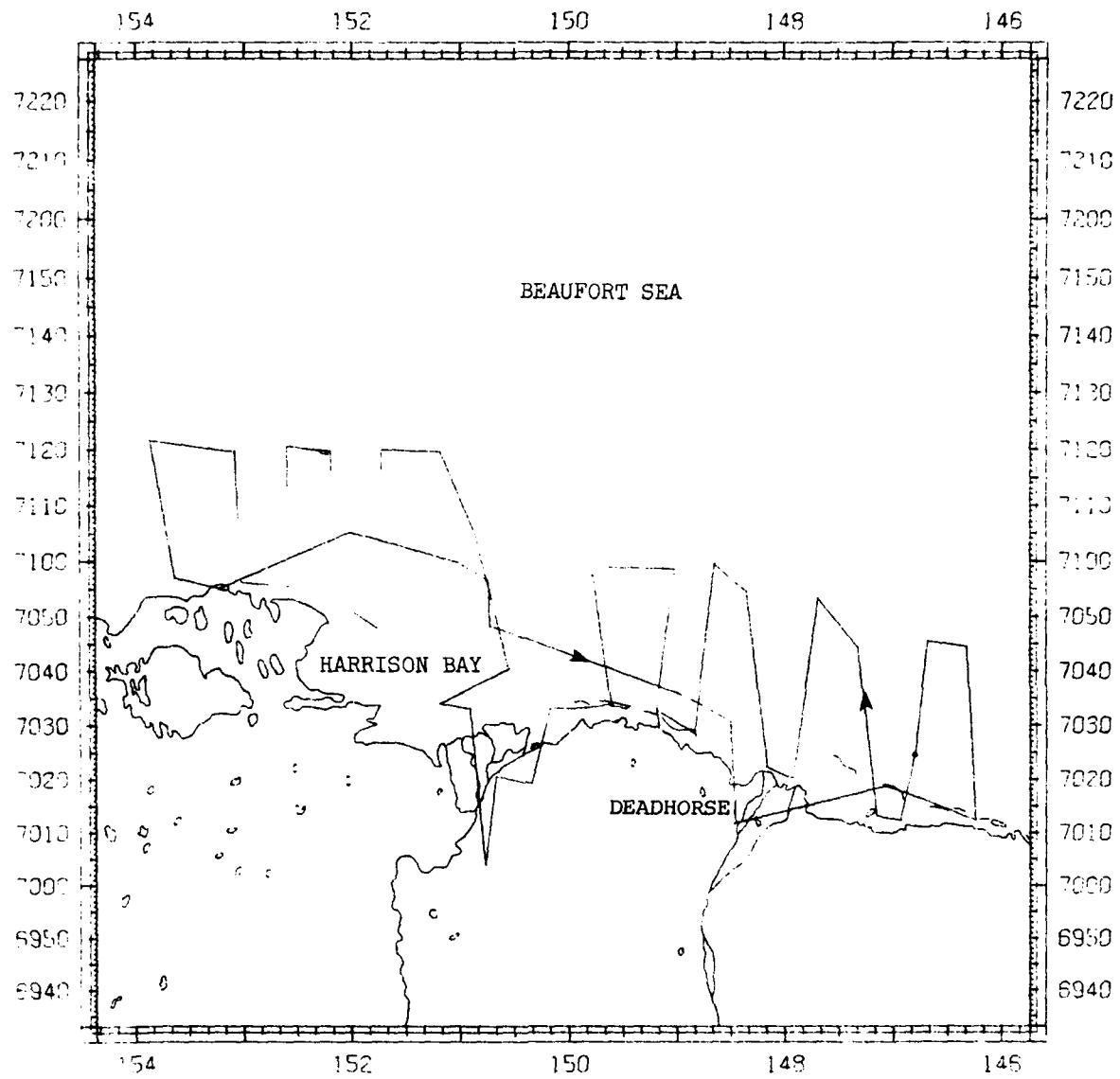
TOTAL 7



FLIGHT 79. 25 September 1980. Two flights from Deadhorse included the Joint State-Federal lease area. Three bowheads were sighted on each flight. All were heading 240° magnetic. Two whales were brown and had white or gray coloration on the head. A sonobuoy was dropped and good sounds were recorded. Two more whales were sighted near the sonobuoy drop location after the survey was completed. These were also heading 240° magnetic. Eight ring seals and 5 bearded seals were also sighted.

Bowhead Whale Sightings for Flight 80, 28 September 1980

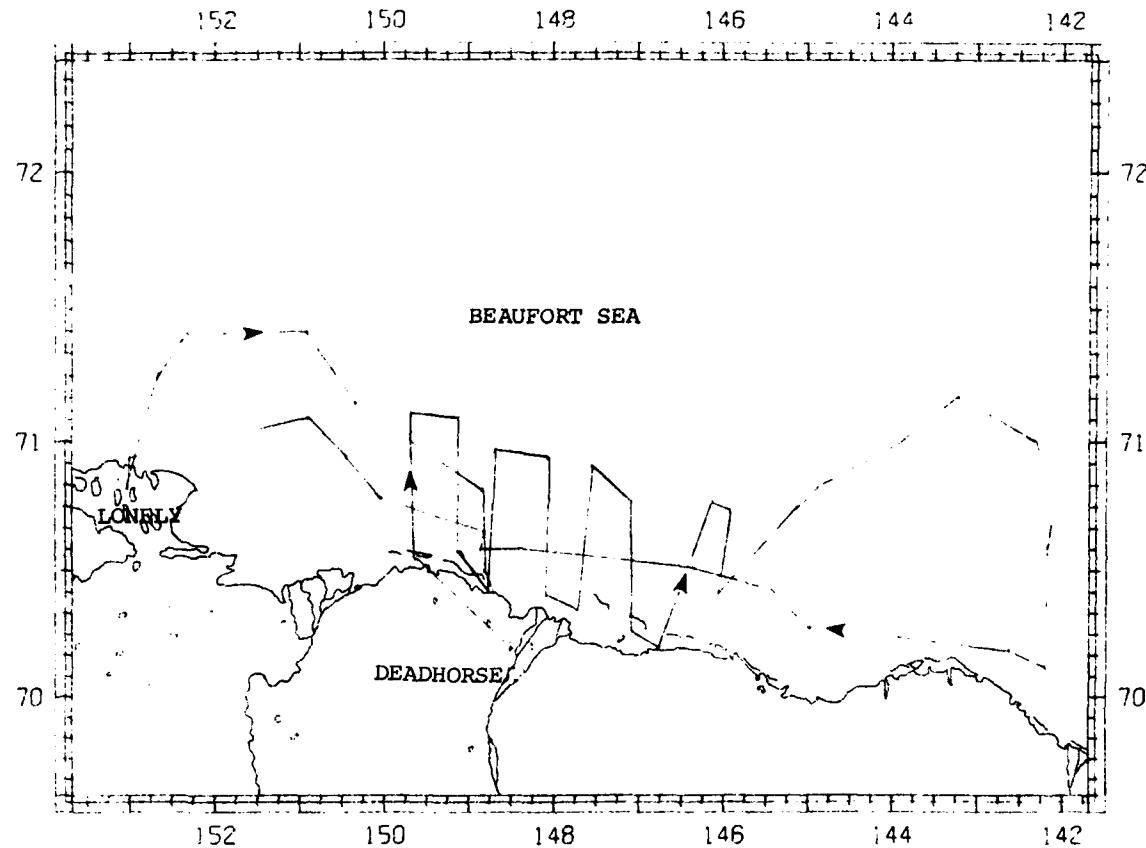
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	146-047.6	70-24.5	150	20	E-270	In open water, dove
TOTAL 1						



FLIGHT 80. 28 September 1980. Flight included the Joint State-Federal and Federal lease areas. One bowhead was sighted heading 270° magnetic. Ice conditions changed so that open water was observed along the 10-fathom line. Elsewhere, ice coverage was 7/10 to 9/10. One ring seal and 5 polar bears were sighted.

No bowhead sightings for flight 81, 30 September 1980

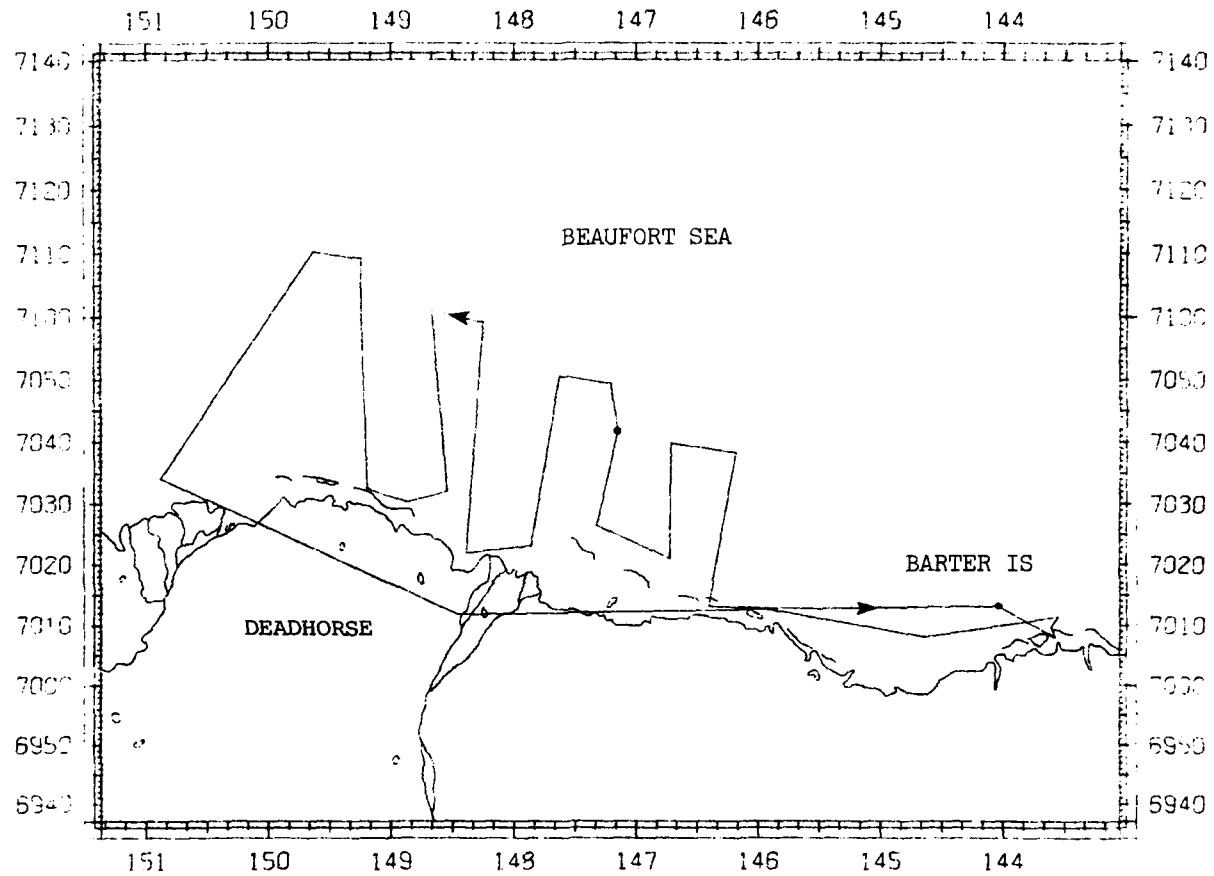
C-160



FLIGHT 81. 30 September 1980. Flight was from Deadhorse through the Joint State-Federal and Federal lease areas north to the pack ice edge, east to Demarcation Bay along the pack ice edge, then west along the 10-fathom line through the Joint State-Federal and Federal lease areas, and returning to Deadhorse. Ice coverage was 7/10 with a large lead near Barter Island. Five ring seals were sighted.

Bowhead Whale Sightings for Flight 82, 2 October 1980

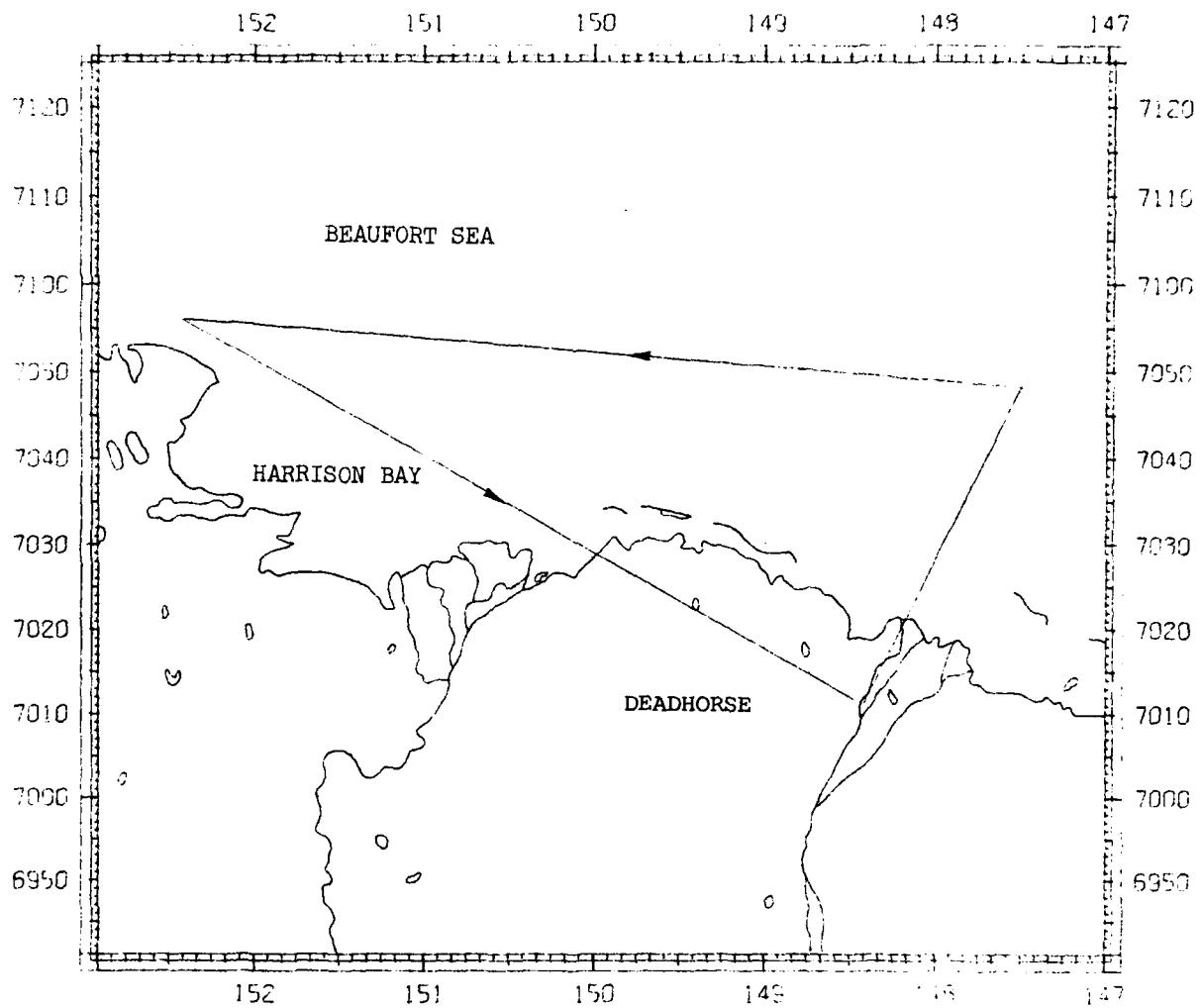
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	144-02.0	70-13.1	150	05	SW-260	In lead
1	147-09.2	70-41.6	120	03	W-270	In small opening in ice, dove
1	147-09.2	70-41.6	120	11	W-270	Dove
TOTAL 3						



FLIGHT 82. 2 October 1980. Flight was from Deadhorse to Barter Island. On return one bowhead heading 270° magnetic was sighted. Survey included the Joint State-Federal lease area. Two bowheads were sighted. The lease area was covered with 7/10 ice. One polar bear was sighted.

No bowhead sightings for flight 83, 3 October 1980

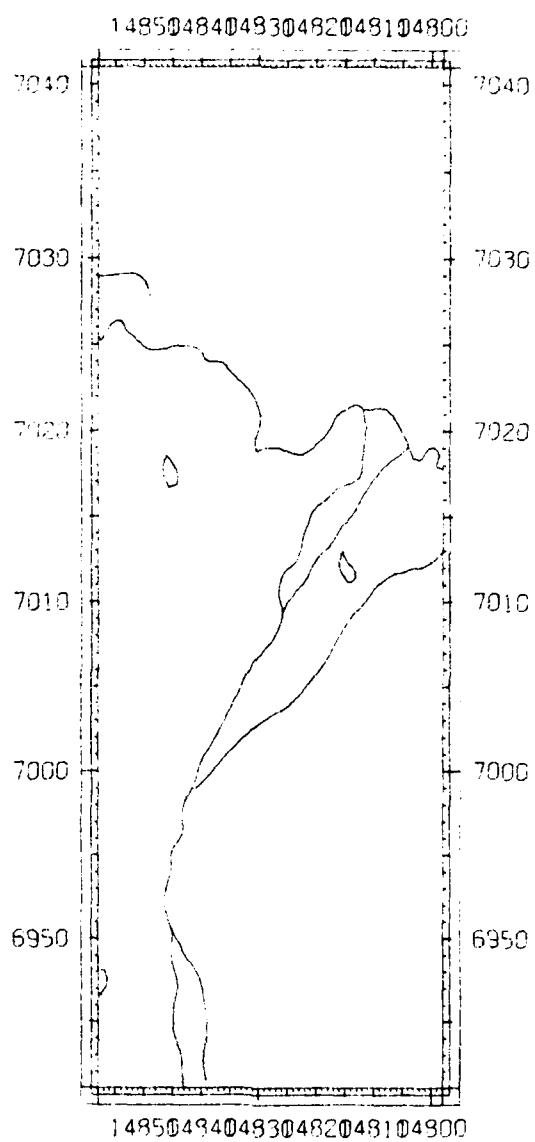
C-164



FLIGHT 83. 3 October 1980. Flight aborted due to severe ice conditions.

No bowhead sightings for flight 84, 5 October 1980

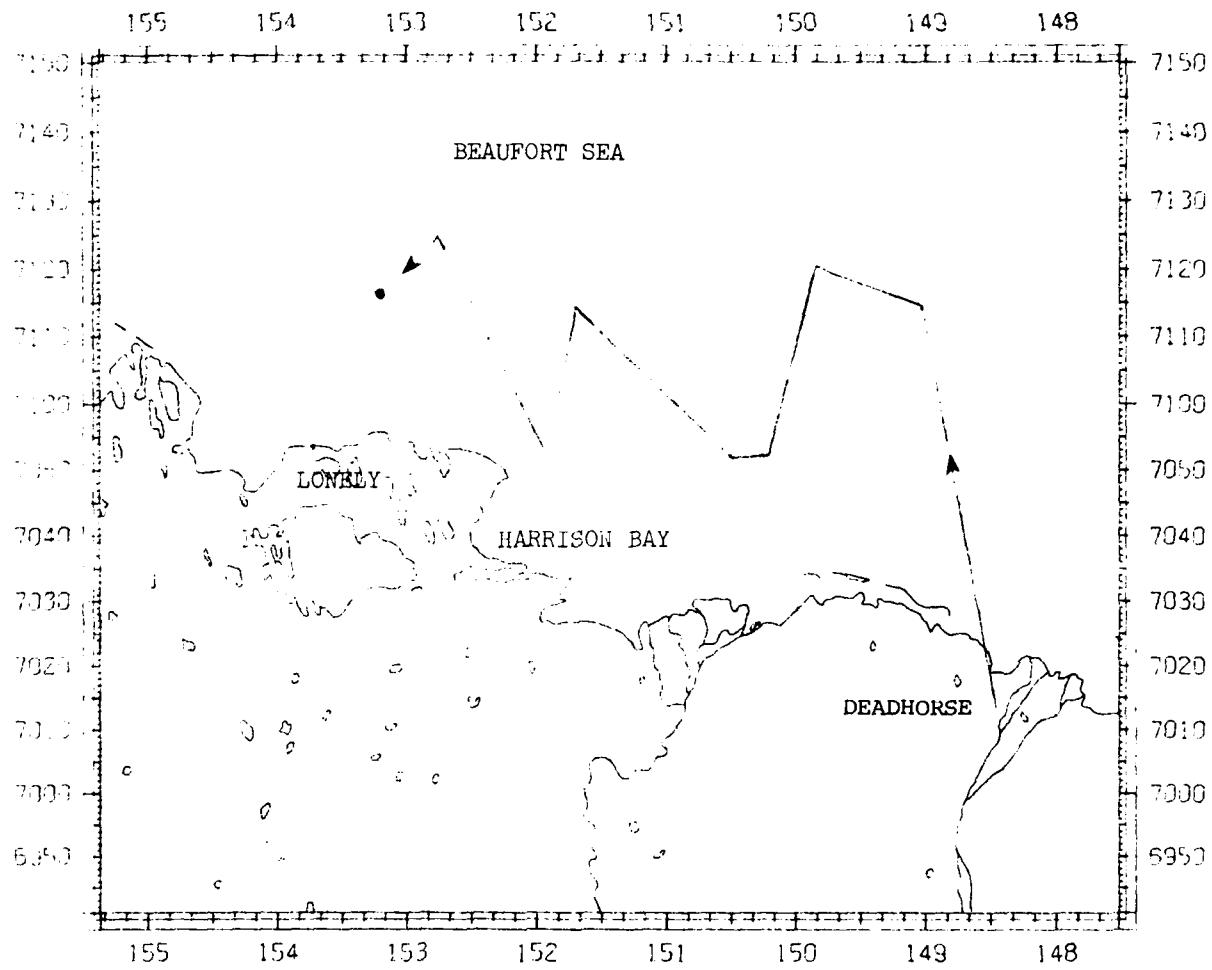
C-166



FLIGHT 84. 5 October 1980. Flight aborted due to weather conditions and failure of GNS.

Bowhead Whale Sightings for Flight 85, 6 October 1980

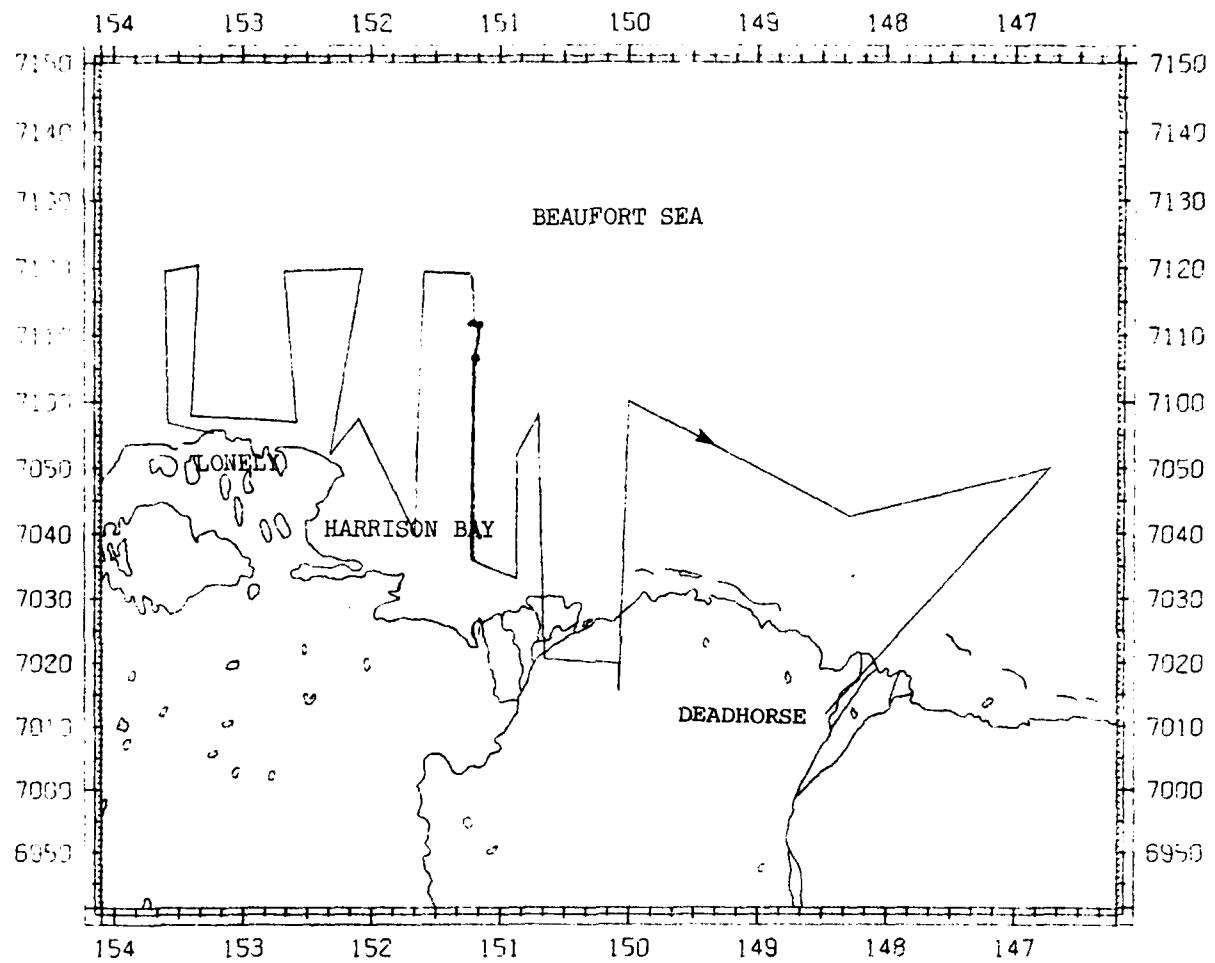
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	153-10.0	71-18.0	150	13	W-270	Dove
TOTAL 1						



FLIGHT 85. 6 October 1980. Flight from Deadhorse included the Federal lease area. Sighted one bowhead heading 270° magnetic. Ice coverage was 7/10.

Bowhead Whale Sightings for Flight 86, 6 October 1980

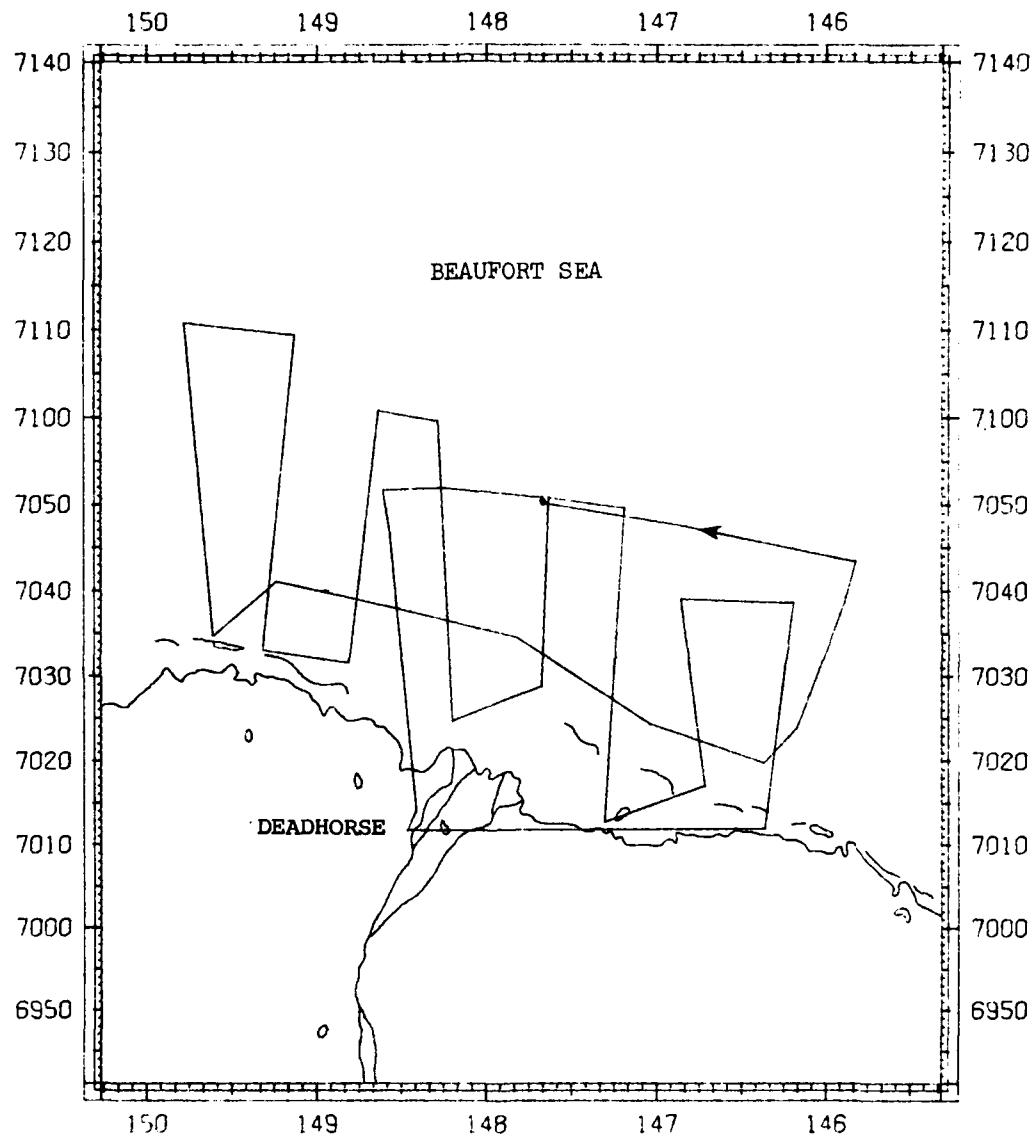
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
1	151-09.4	71-12.3	300	12	W-270	In lead
1	151-09.5	71-11.5	300	48	W-270	Dove
2	151-09.5	71-11.5	240	35	W-270	Dove
TOTAL 4						



FLIGHT 86. 6 October 1980. Flight included the Federal lease area. Sighted 4 bowheads all heading 270° magnetic. Flew east along the 10-fathom line and north following leads in the ice. Sighted beluga cow-calf heading 250° magnetic. Ice conditions had opened up along the 10-fathom line. One ring seal was sighted.

Bowhead Whale Sightings for Flight 87, 8 October 1980

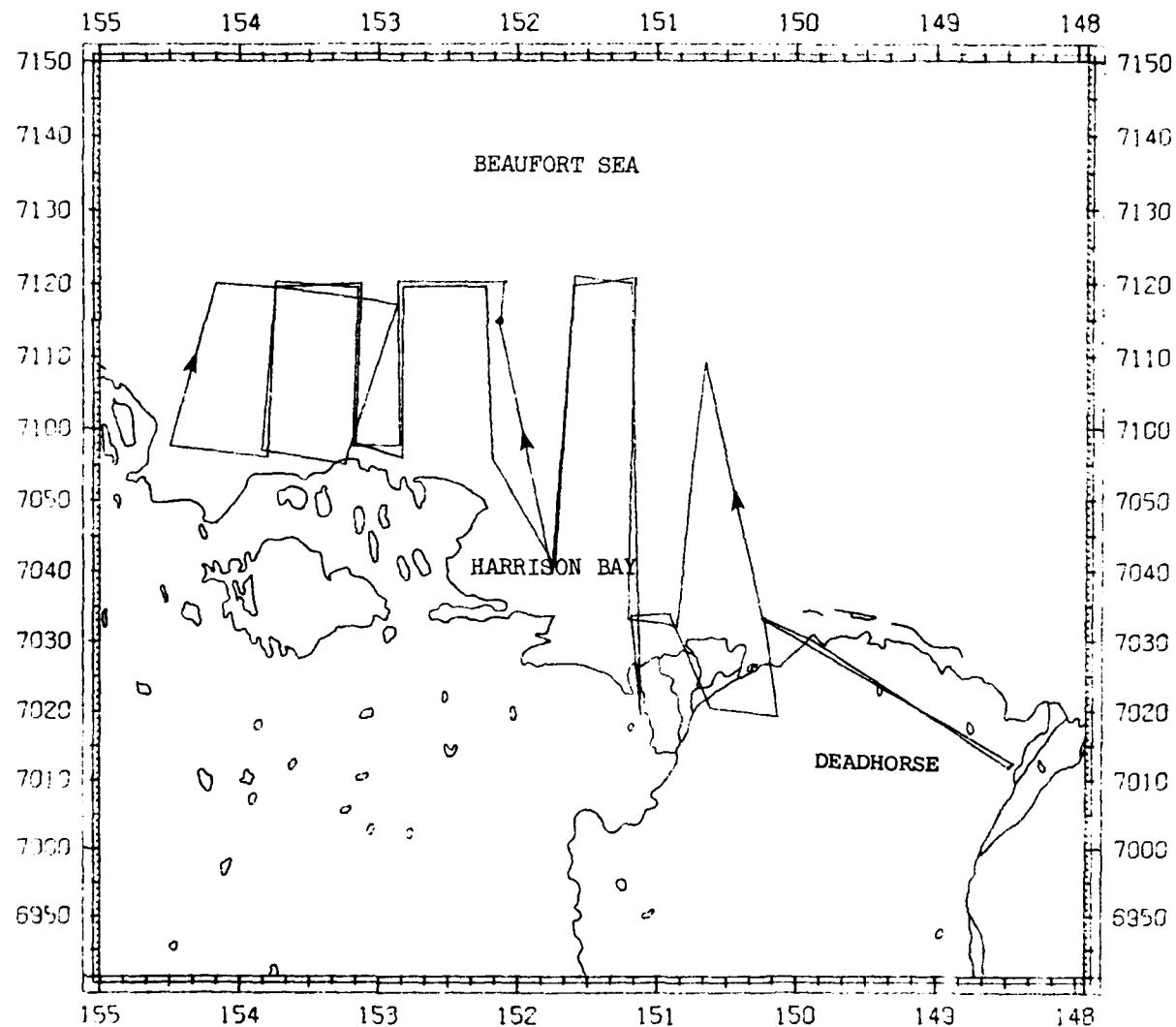
Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
2	147-39.9	70-50.2	180	21	W-270	Second spotted while circling; dove
TOTAL 2						



FLIGHT 87. 8 October 1980. Flight included the Joint State-Federal and Federal lease areas and then west along the 10-fathom line. Sighted two bowheads heading 270° magnetic. Ice coverage was 7/10.

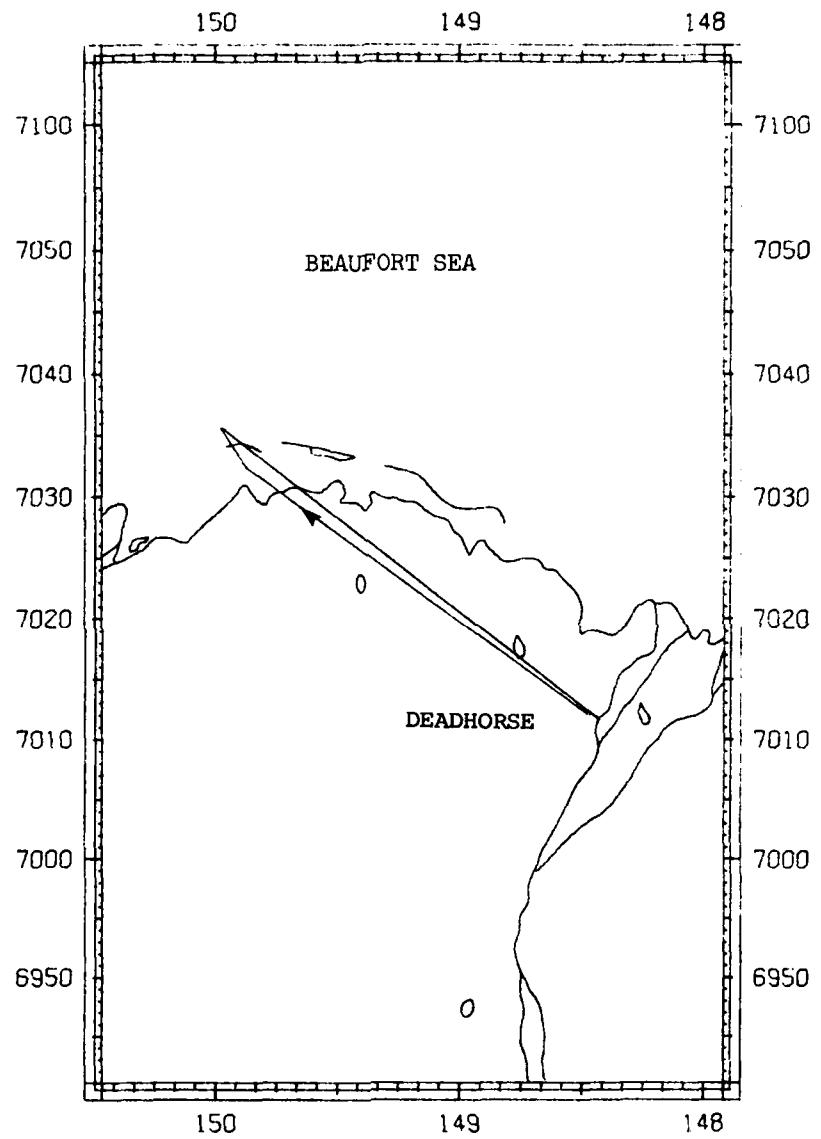
Bowhead Whale Sightings for Flight 88, 9 October 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Clinometer Angle	Heading (Magnetic)	Behavior and Observations
2	152-07.7	71-14.6	270	5	NW-305	Cow-calf pair, in small hole in ice, dove
TOTAL 2						



FLIGHT 88. 9 October 1980. Flight included two surveys of the Federal lease area. Sighted a 13- to 15-m cow and a 4- to 5-m calf bowhead lying still in a small lead. Four polar bears and 1 bearded seal were sighted.

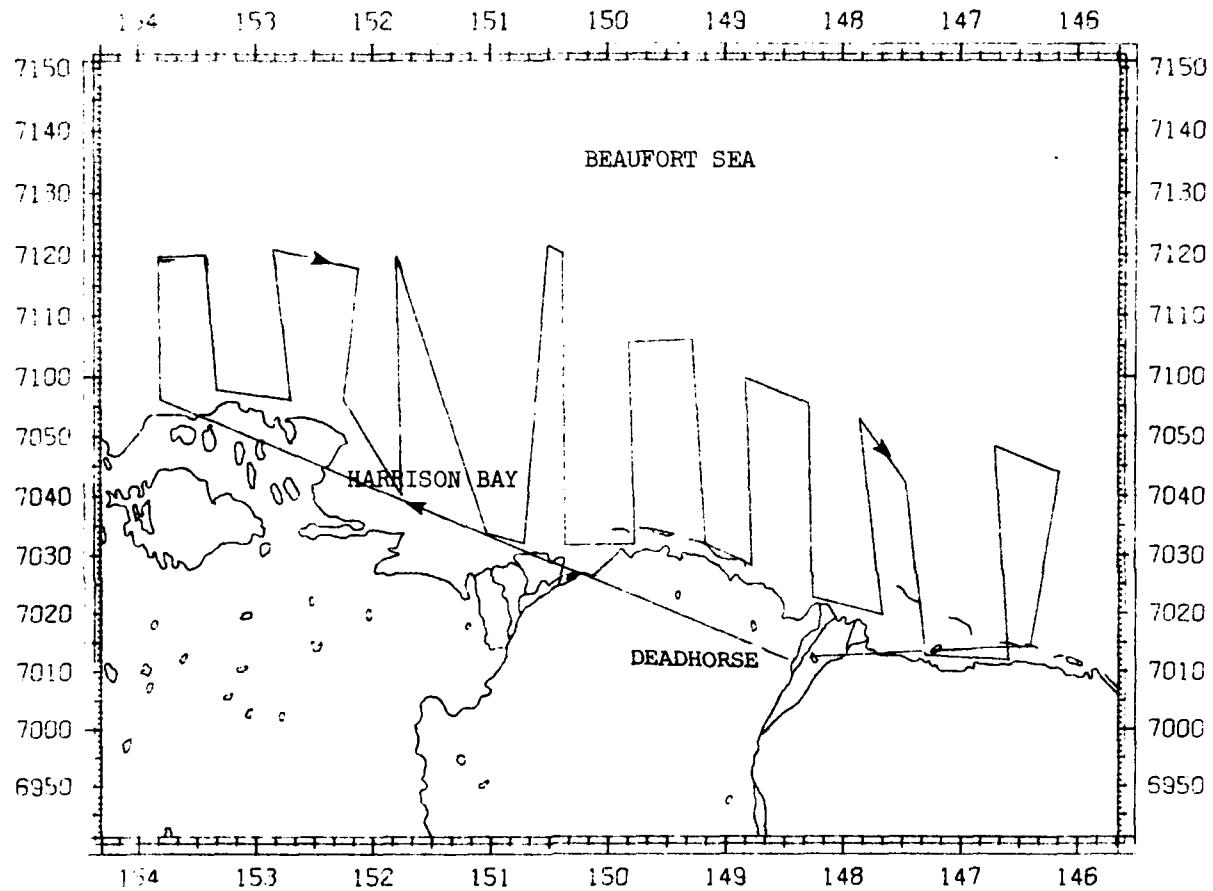
No bowhead sightings for flight 89, 11 October 1980



FLIGHT 89. 11 October 1980. Survey aborted due to weather conditions.

No bowhead sightings for flight 90, 12 October 1980

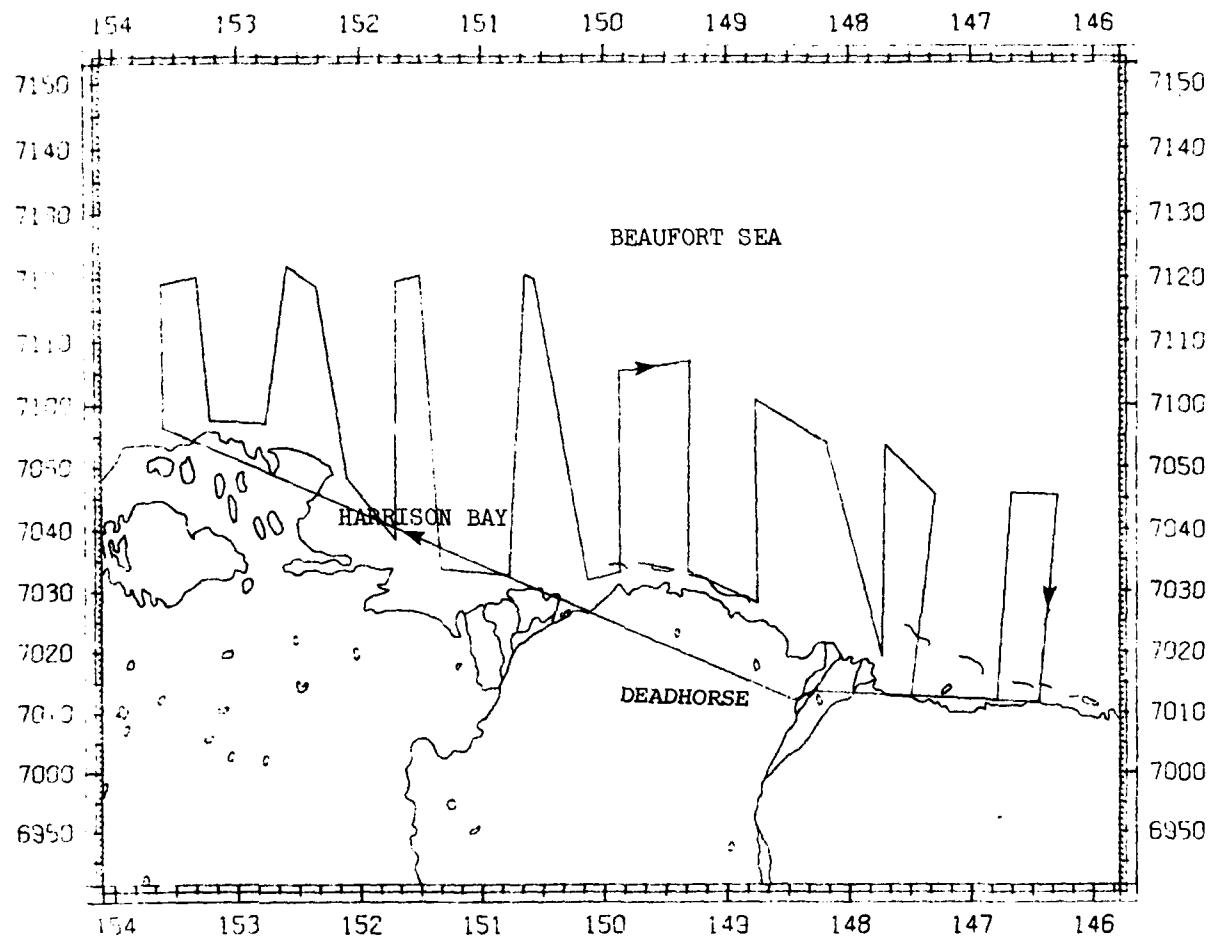
C-178



FLIGHT 90. 12 October 1980. Flight included Federal and Joint State-Federal lease areas. One sighting of 2 polar bears was made. Ice coverage ranged from 7/10 to 8/10.

No bowhead sightings for flight 91, 13 October 1980

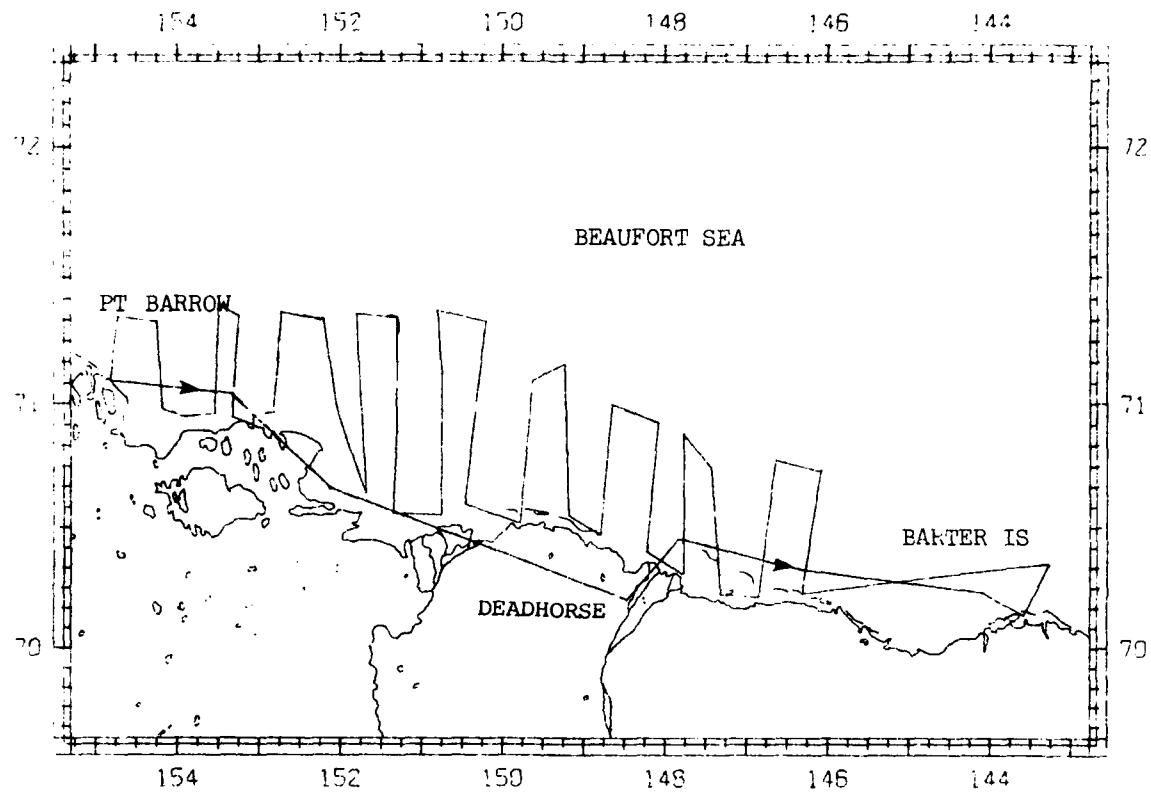
C-180



FLIGHT 91. 13 October 1980. Flight included Federal and Joint State-Federal lease areas. No sightings. Ice coverage ranged from 7/10 to 9/10.

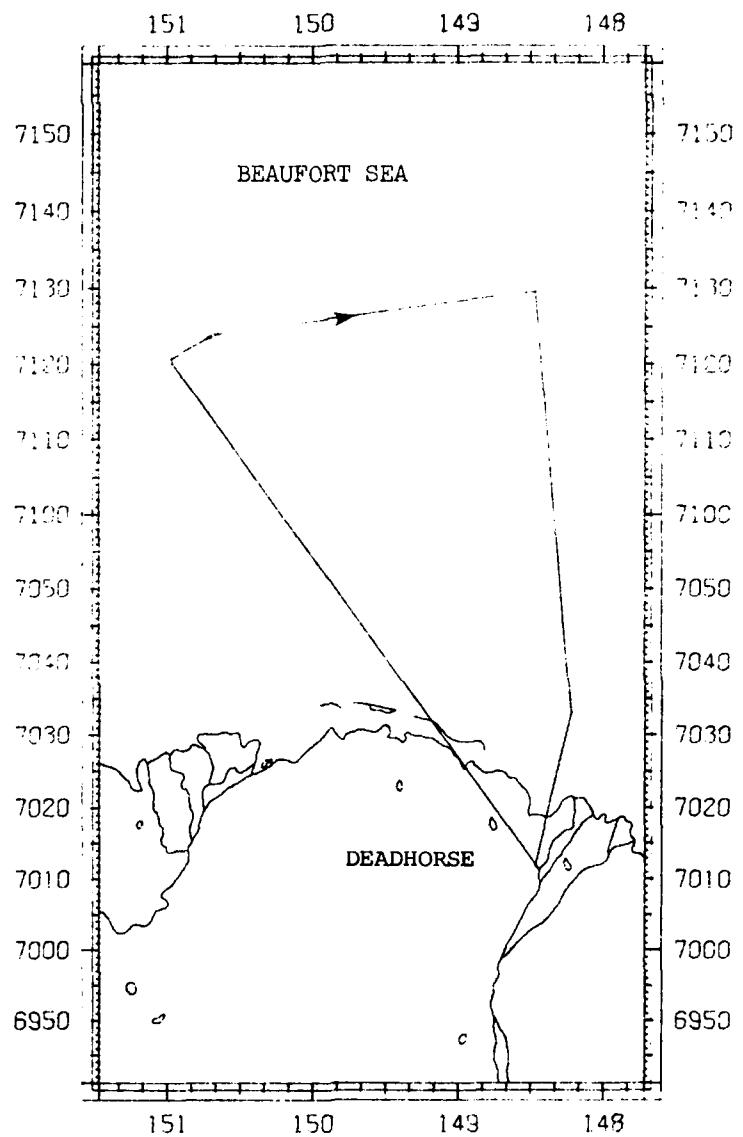
No bowhead sightings for flight 92, 14 October 1980

C-182



FLIGHT 92. 14 October 1980. Flight included Joint State-Federal and Federal lease areas. No whales sighted. Two ring seals, 2 bearded seals, 2 polar bears, and 1 grizzly bear were sighted. Ice coverage ranged from 7/10 to 9/10.

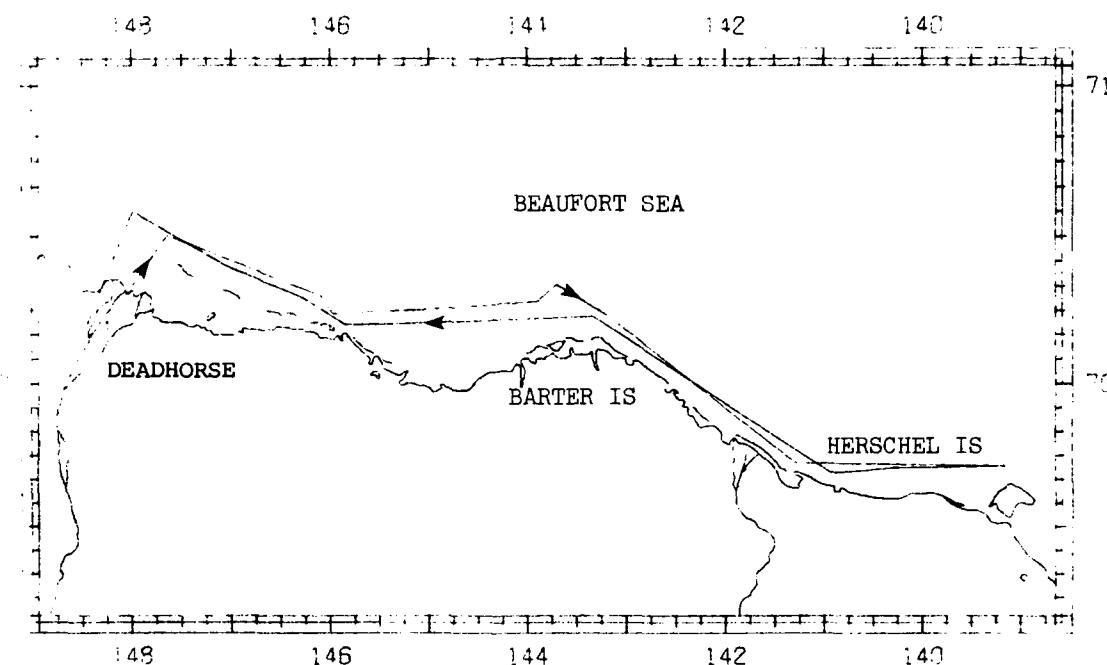
No bowhead sightings for flight 93, 15 October 1980



FLIGHT 93. 15 October 1980. Flight was from Deadhorse north of Joint State-Federal lease area. One sighting of 2 polar bears was made. Ice coverage averaged about 8/10.

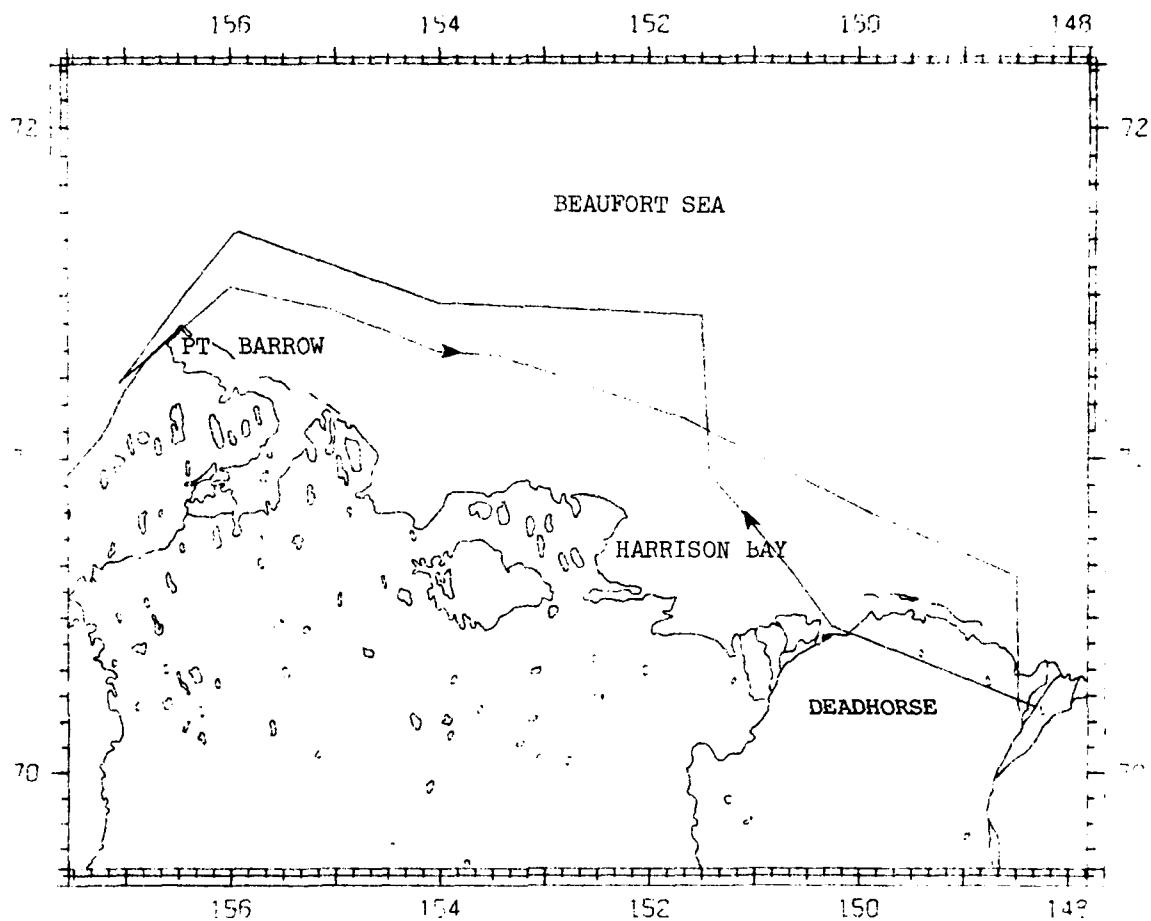
No bowhead sightings for flight 94, 21 October 1980

C-186



FLIGHT 94. 21 October 1980. Flight was from Deadhorse to Herschel Island and back to Deadhorse. Eleven ring seals, 1 bearded seal, and 1 polar bear were sighted. Ice coverage ranged from 6/10 to 9/10 solid ice.

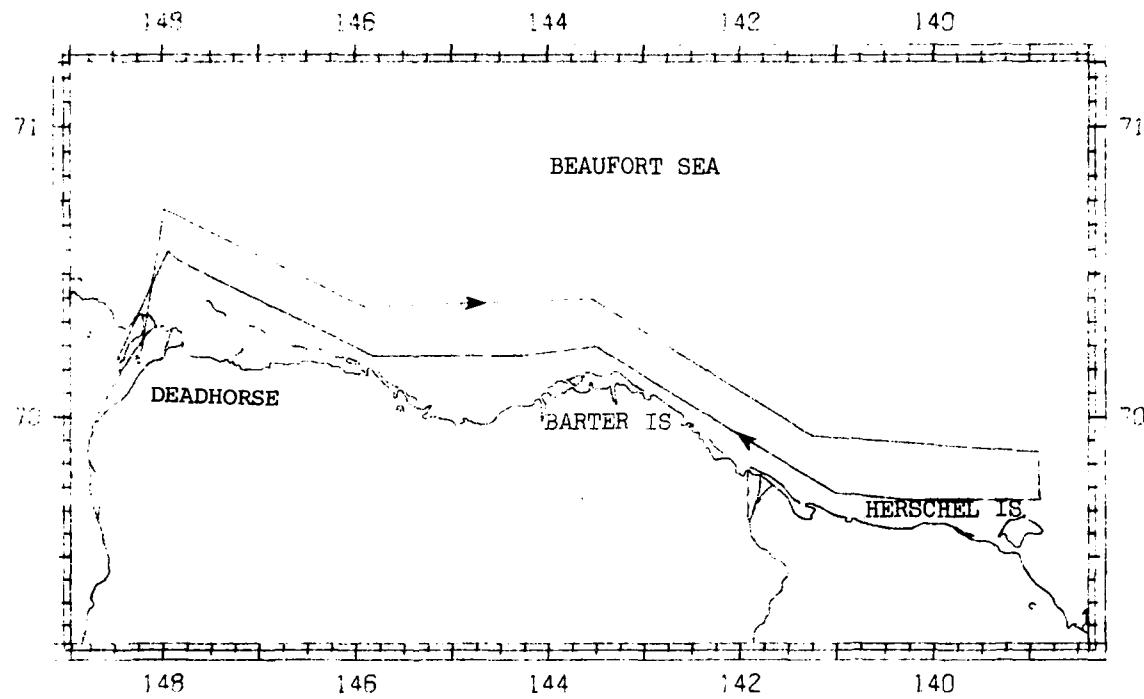
No bowhead sightings for flight 95, 22 October 1980



FLIGHT 95. 22 October 1980. Flight was from Deadhorse west to Pt. Barrow through the Federal lease area and back to Deadhorse. One polar bear was sighted. To the west of Pt. Barrow, the sea appeared to be free of ice south of $71^{\circ}18.5' N$, $156^{\circ}55.7' W$.

No bowhead sightings for flight 96, 24 October 1980

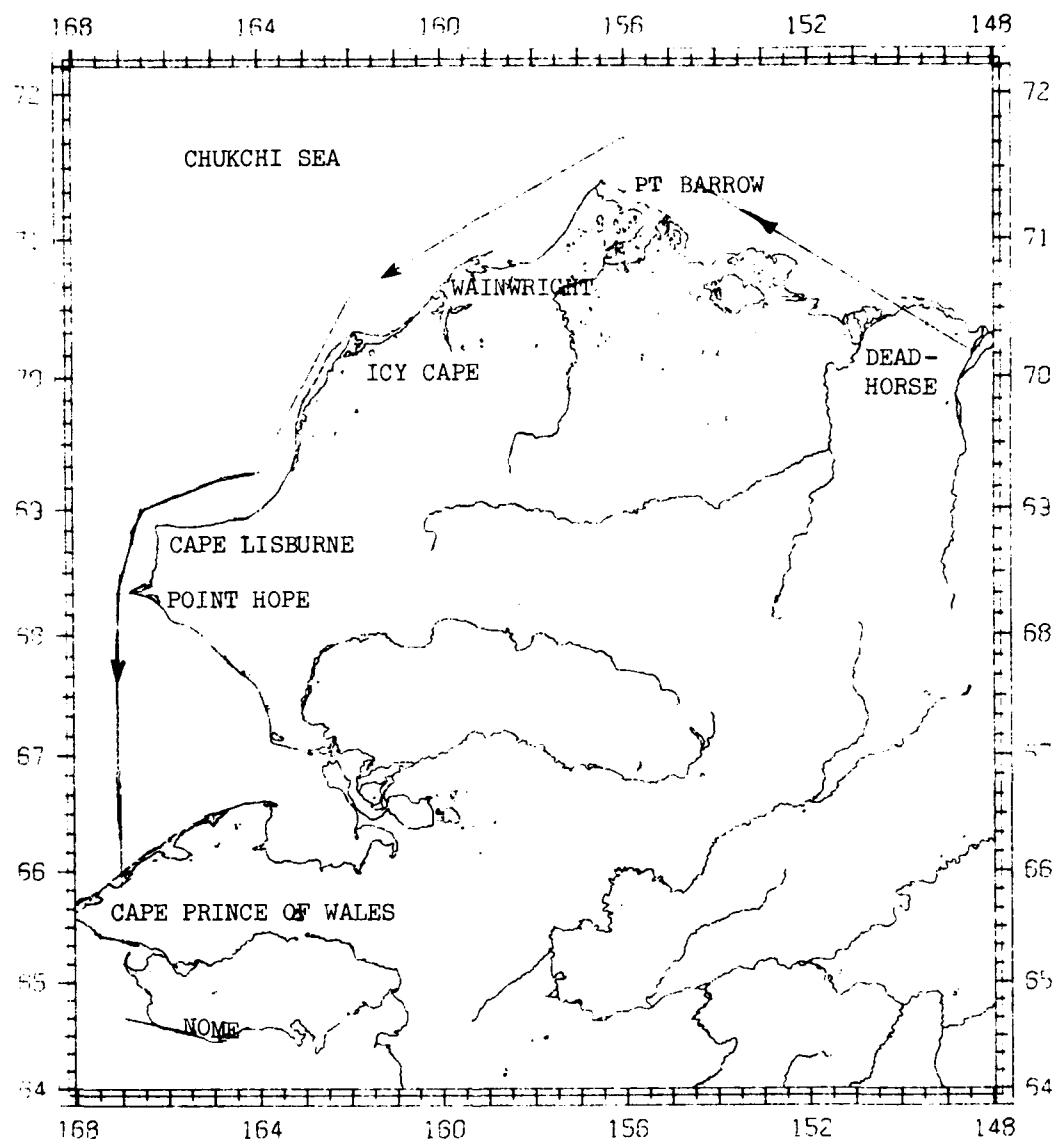
C-190



FLIGHT 96. 24 October 1980. Flight was from Deadhorse through the Joint State-Federal lease area and back to Deadhorse. Two pinnipeds were sighted.

No bowhead sightings for flight 97, 25 October 1980

C-192

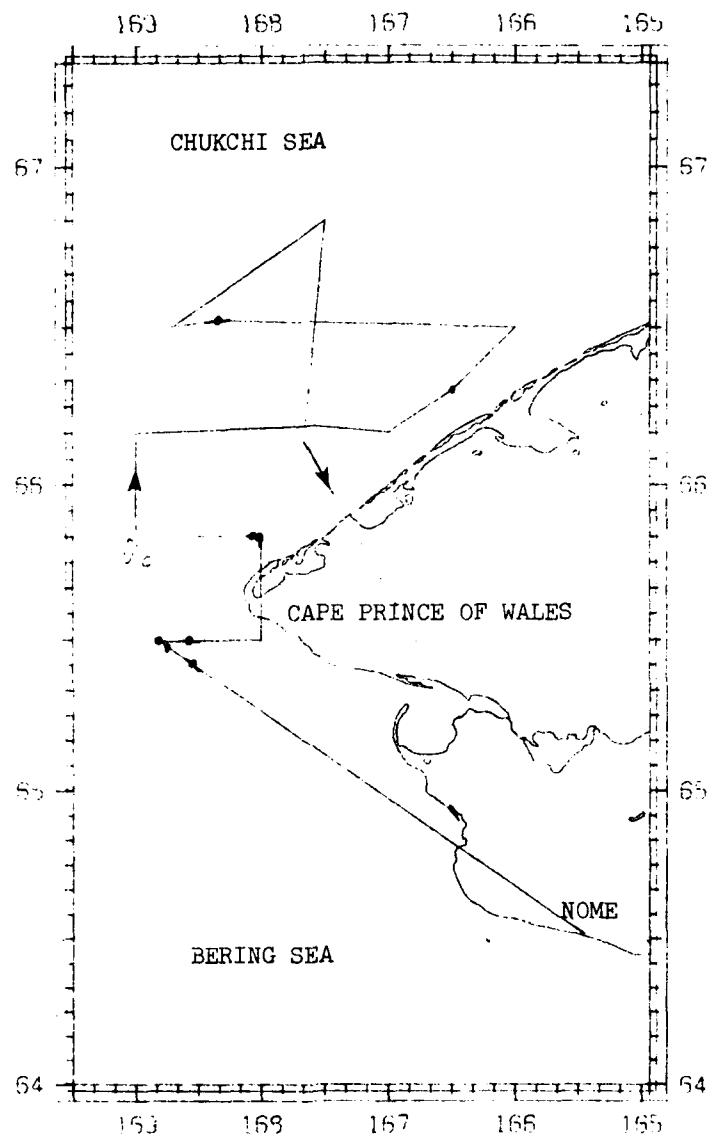


FLIGHT 97. 25 October 1980. Coastal flight from Deadhorse to Nome. Low fog extended from Prudhoe Bay, around Point Barrow, and south to around Icy Cape. The Chukchi Sea was covered with 9/10 new ice and open water from Icy Cape to just north of Cape Lisburne. From this point on, the sea was generally open, with sea state ranging on the Beaufort scale from 2 to 5. No whales or polar bears were sighted. Three sightings of 3 individual pinnipeds were made.

No bowhead sightings for flight 98, 26 October 1980

Gray Whale Sightings for Flight 98, 26 October 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
14	168-33.1	65-25.4	300
2	168-51.0	65-30.6	300
8	169-00.0	65-30.0	330
1	168-35.1	65-29.8	330
1	168-00.0	65-50.0	330
1	168-01.5	65-50.2	300
1	166-30.0	66-18.1	300
1	168-20.5	66-31.3	300
TOTAL 29			



FLIGHT 98. 26 October 1980. Flight was north of Bering Straits. Thirteen sightings of 29 gray whales and 1 unidentified whale were made. No ice was present.

No bowhead sightings for flight 99, 27 October 1980

Gray Whale Sightings for Flight 99, 27 October 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
2	167-52.6	64-12.4	450
1	168-03.0	64-16.1	300
6	168-18.2	64-09.0	300
1	168-29.0	64-11.7	360
2	168-43.0	64-09.7	330
9	169-36.7	64-22.2	300
2	169-24.0	64-23.9	300
1	169-08.7	64-25.0	330
1	168-37.3	64-25.3	300
1	168-26.9	64-24.4	270
2	168-20.0	64-25.4	300
2	168-33.9	64-46.8	300
2	168-56.2	64-45.6	300
1	168-58.7	64-45.4	300
11	169-07.2	64-45.6	300
1	169-15.4	64-44.1	300
2	169-18.6	64-43.3	300
9	169-33.0	64-42.2	300
1	169-40.9	64-41.4	300
1	169-50.2	64-40.7	300
2	169-45.8	64-41.2	300
1	169-37.6	64-40.6	300
1	169-21.6	64-39.1	300
2	169-21.6	64-39.1	300
3	169-21.6	64-39.1	300
1	169-43.7	64-37.1	300

TOTAL 68

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AERIAL SURVEYS OF ENDANGERED WHALES IN THE BEAUPORT SEA, CHUKCHI-ETC(U)
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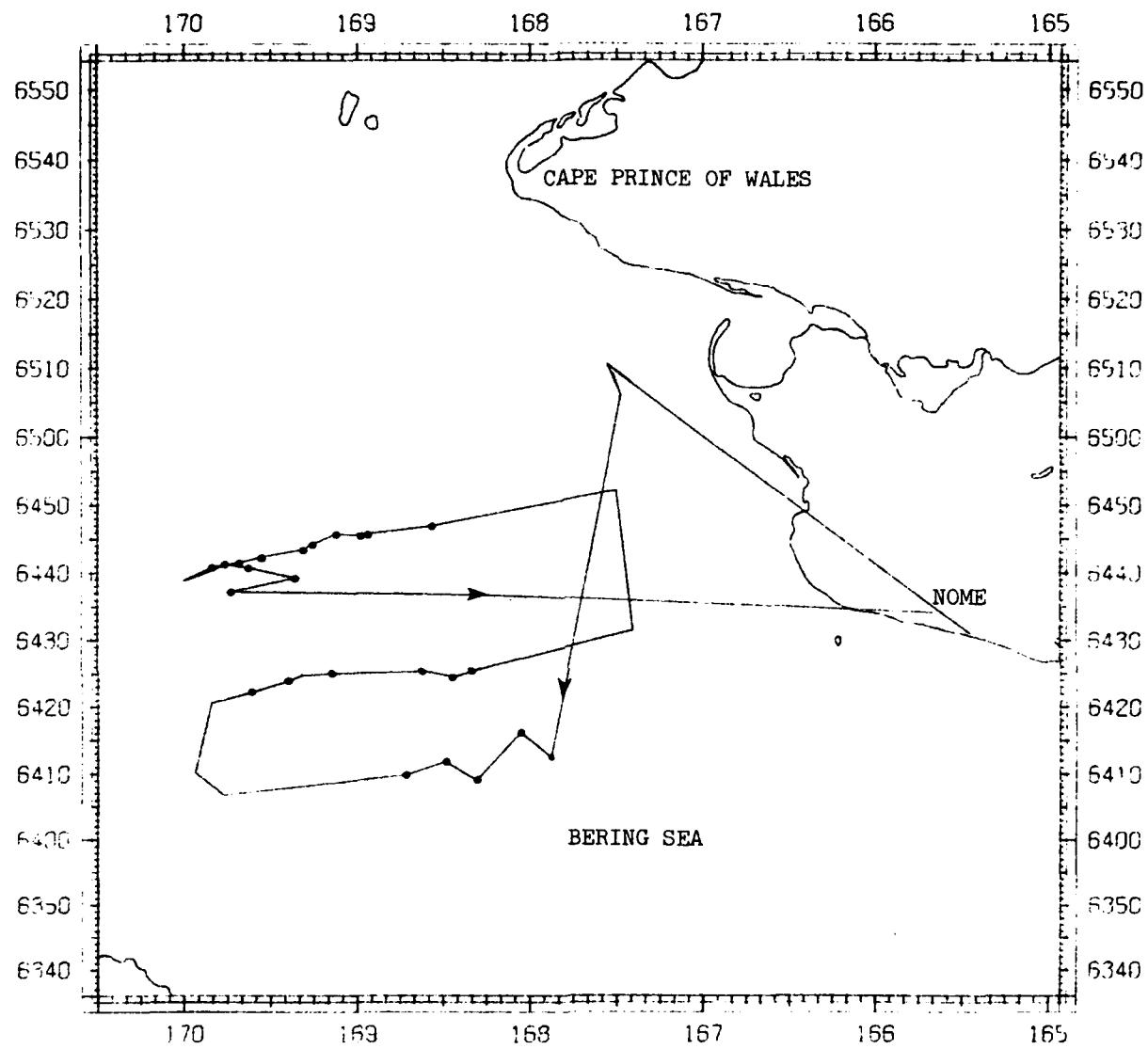
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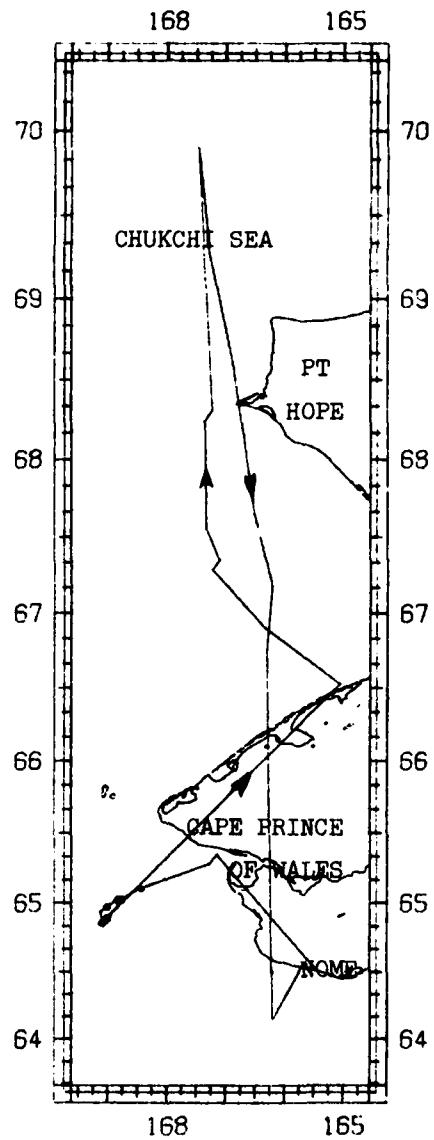


FLIGHT 99. 27 October 1980. Flight was south of Bering Straits. Twenty-six sightings of 68 gray whales and 1 unidentified whale were made. No ice was present.

No bowhead sightings for flight 100, 28 October 1980

Gray Whale Sightings for Flight 100, 28 October 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
6	168-25.8	65-06.2	180
2	168-46.5	65-01.4	210
1	168-49.2	65-01.5	210
2	169-00.3	64-58.2	210
4	169-05.0	64-51.4	240
5	169-00.3	64-53.3	600
TOTAL 20			

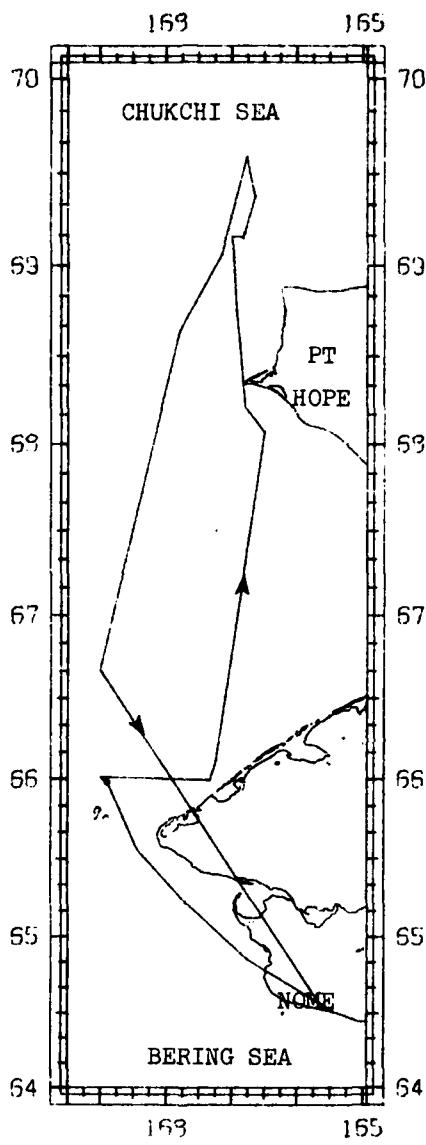


FLIGHT 100. 28 October 1980. Flight was north of Bering Straits, coastal to Pt. Hope. Six sightings of 20 gray whales and 1 sighting of 1 pinniped were made. No ice was present.

No bowhead sightings for flight 101, 29 October 1980

Gray Whale Sightings for Flight 101, 29 October 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
2	168-53.1	65-58.7	270
TOTAL 2			

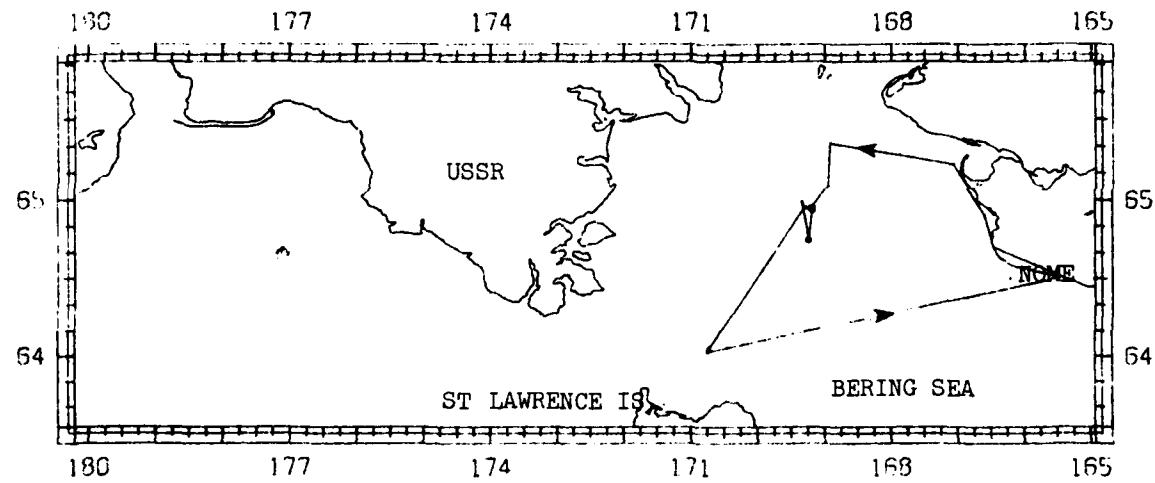


FLIGHT 101. 29 October 1980. Flight was north of Bering Straits. One sighting of 2 gray whales was made. No ice was present.

No bowhead sightings for flight 102, 30 October 1980

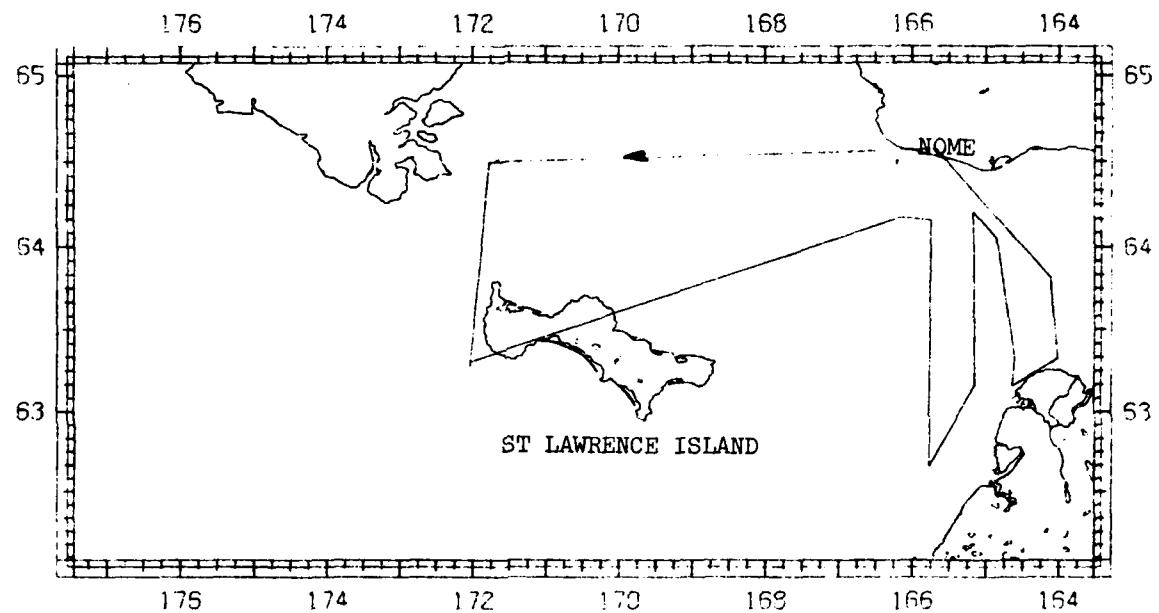
Gray Whale Sightings for Flight 102, 30 October 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
1	169-10.6	64-57.0	
1	169-14.0	64-44.8	
1	169-10.8	64-56.2	
TOTAL 3			



FLIGHT 102. 30 October 1980. Flight was to the Bering Sea. Three gray whales and 1 pinniped were sighted. One sonobuoy was dropped. No ice was present.

No bowhead or gray whale sightings for flight 103, 1 November 1980

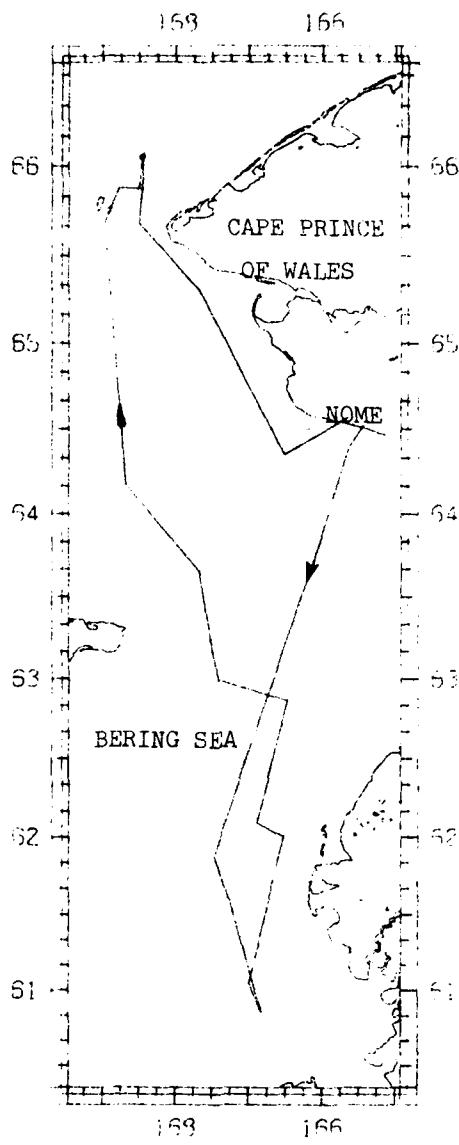


FLIGHT 103. 1 November 1980. Flight was to the Bering Sea and Norton Sound. No sightings. No ice was present.

No bowhead sightings for flight 104, 2 November 1980

Gray Whale Sightings for Flight 104, 2 November 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
1	168-27.5	66-03.0	270
TOTAL 1			



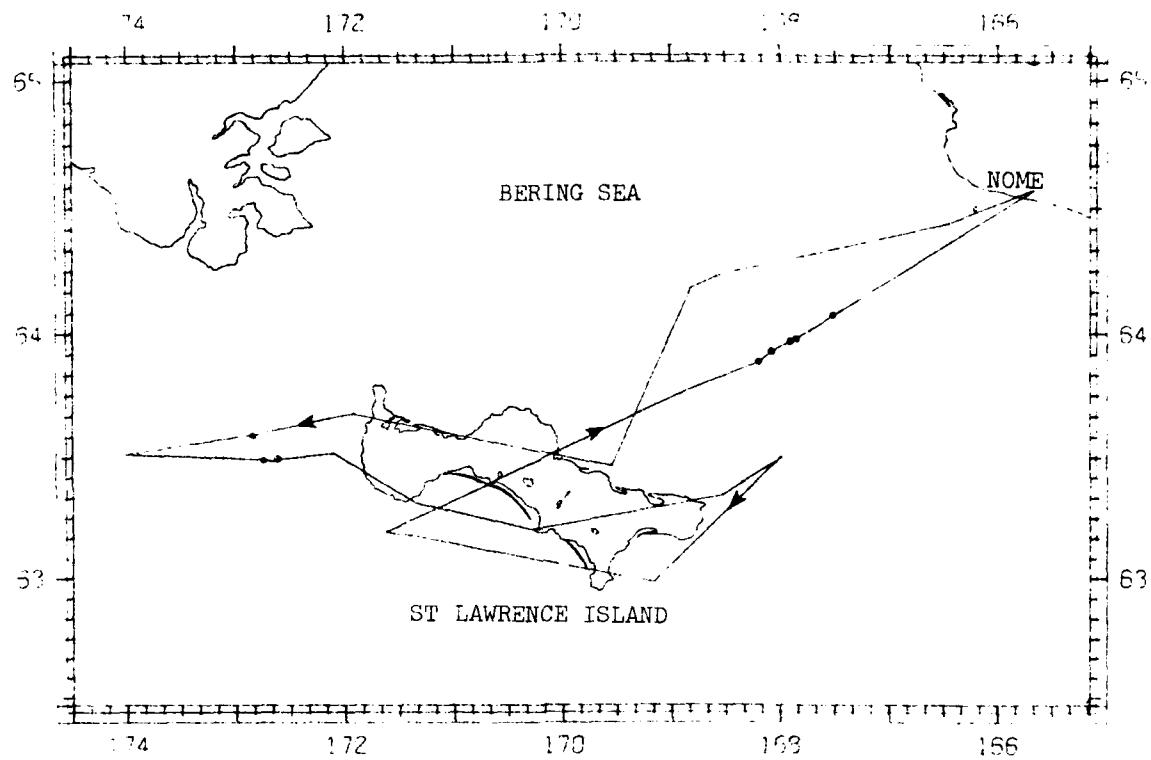
FLIGHT 104. 2 November 1980. Flight was to the Bering Sea and Straits. One gray whale was sighted. One sonobuoy was dropped. No ice was present.

No bowhead sightings for flight 105, 3 November 1980

Gray Whale Sightings for Flight 105, 3 November 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
1	172-50.5	63-35.4	270
2	172-44.6	63-29.3	300
2	172-37.0	63-29.6	300
1	170-36.1	63-06.5	300
2	168-11.4	63-53.1	300
1	168-04.4	63-55.8	240
1	167-54.2	63-58.1	270
1	167-50.9	63-58.8	240

TOTAL 11

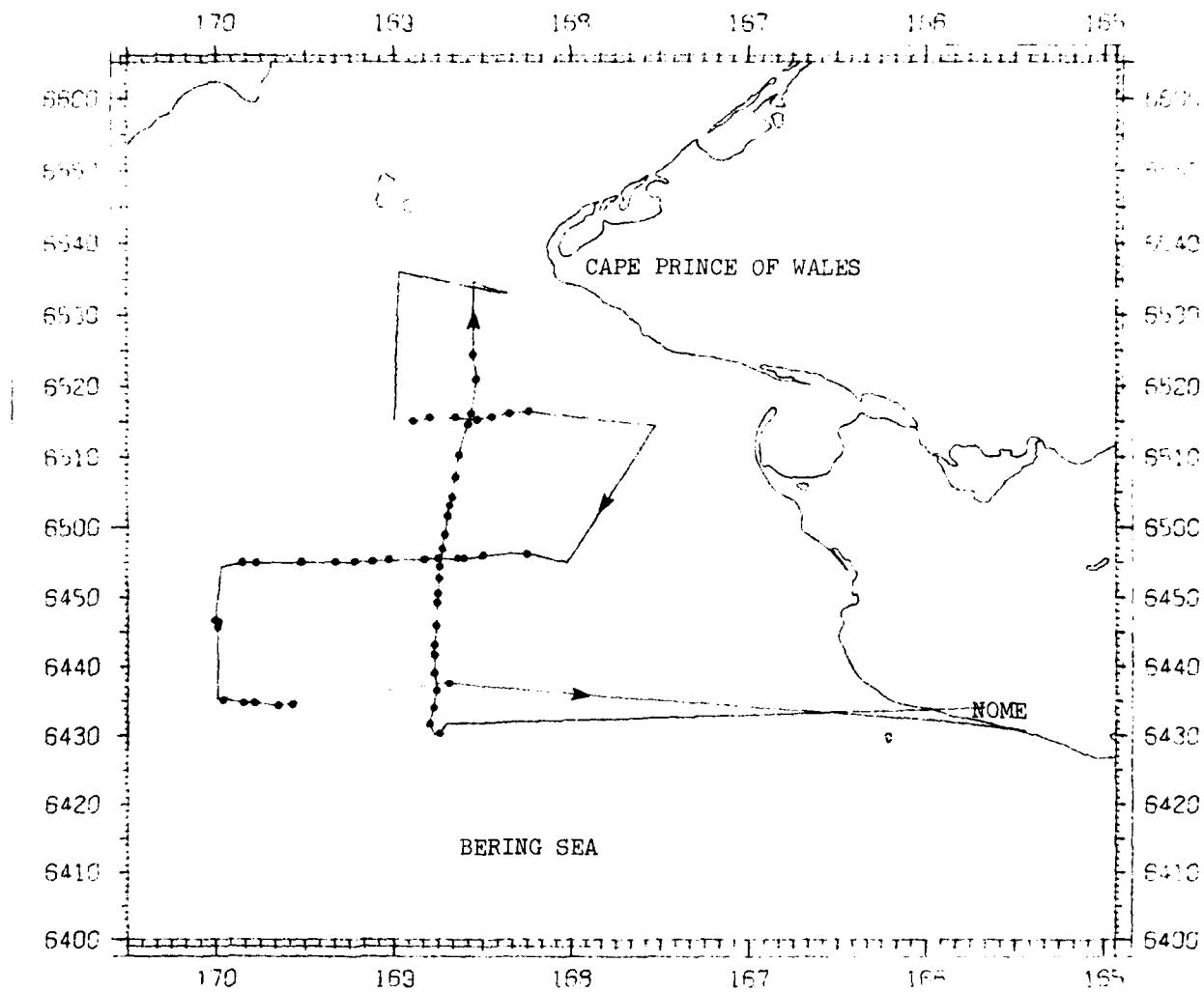


FLIGHT 105. 3 November 1980. Flight was to St. Lawrence Island. Eleven gray whales and 1 unidentified whale were sighted. One walrus was sighted. One sonobuoy was dropped. No ice was present.

No bowhead sightings for flight 106, 4 November 1980

Gray Whale Sightings for Flight 106, 4 November 1980

Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)	Number of Whales	Longitude (West)	Latitude (North)	Altitude (Meters)
25	168-41.3	64-37.4	300	2	168-47.8	65-15.5	300
3	169-34.0	64-34.6	300	3	168-53.4	65-15.1	300
2	169-38.9	64-34.4	300	2	168-33.1	65-24.5	300
1	169-47.0	64-34.8	300	2	168-32.0	65-21.0	300
1	169-50.7	64-34.8	300	1	168-33.7	65-16.2	300
1	169-57.5	64-35.2	300	2	168-34.9	65-14.7	300
1	169-59.5	64-45.7	300	1	168-38.0	65-10.3	300
1	169-59.3	64-46.4	300	2	168-39.1	65-07.2	300
1	170-00.4	64-46.7	300	1	168-40.2	65-04.3	300
2	169-51.3	64-55.0	300	6	168-40.4	65-03.2	300
1	169-46.5	64-54.9	300	5	168-41.8	65-01.7	300
6	169-31.3	64-55.0	300	3	168-42.9	64-59.0	300
3	169-19.7	64-55.1	300	2	168-43.6	64-56.9	300
2	169-13.2	64-55.1	300	1	168-44.4	64-54.4	300
2	169-07.3	64-55.2	300	1	168-44.7	64-52.7	300
3	168-01.8	64-55.4	300	1	168-45.1	64-50.5	300
3	168-49.7	64-55.5	300	1	168-45.3	64-49.2	300
1	168-45.1	64-55.6	300	1	168-45.7	64-45.9	300
1	168-38.5	64-55.6	300	1	168-46.2	64-43.1	300
2	168-36.3	64-55.6	300	2	168-46.4	64-41.7	300
3	168-30.0	64-56.0	300	3	168-46.3	64-39.0	300
2	168-15.0	64-56.2	300	1	168-45.6	64-36.5	300
1	168-14.3	65-16.5	300	1	168-46.4	64-34.0	300
2	168-20.8	65-16.1	300	2	168-47.9	64-31.7	300
1	168-26.9	65-15.7	300	1	168-44.5	64-30.3	300
1	168-31.8	65-15.3	300	TOTAL 122			
2	168-39.1	65-15.6	300				



FLIGHT 106. 4 November 1980. Flight was to the Bering Sea. Sighted 123 gray whales, one of which was dead. One pinniped was sighted. One sonobuoy was dropped. Small amounts of grease ice were present.

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